# *Lighting II*

ARC 3723 | EBS II
MS State University | CAAD

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## Lighting

### Light Sources

Primary sources of electric light for buildings

Incandescent
Discharge
Solid State

Relative efficacy of various light sources

Efficacy = lumens per watt

Spectral distribution (color) also influences efficacy of lamps. For example, warm white lamps have a lower efficacy than cool white lamps.

*(Source: Heating, Cooling, Lighting by Lechner)*

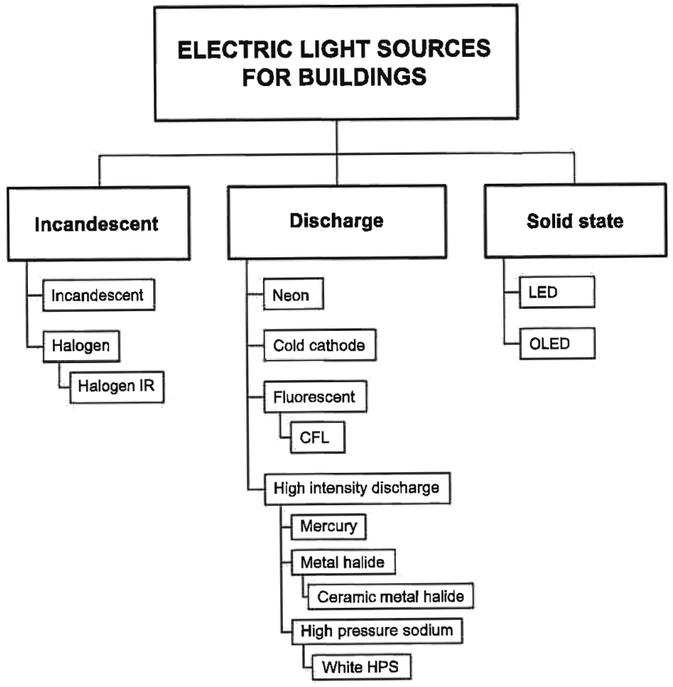


**Figure 16.2a** This chart shows the sources of electric light for buildings. Until recently, discharge lamps were the primary light source, but they are being replaced by the solid-state sources. Abbreviations: LED (light-emitting diode), OLED (organic light-emitting diodes), CFL (compact fluorescent lamp), IR (Infrared) and HPS (high-pressure sodium) lamp.

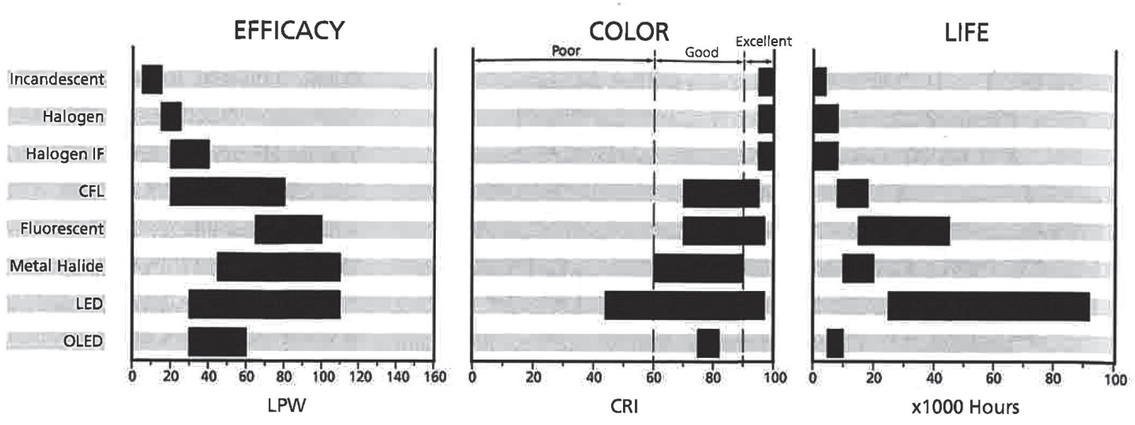


**Figure 16.2b** In choosing a lamp, the three main characteristics are efficacy (lumens per watt), color rendering (CRI), and the life of the lamp. To make comparisons easier, all three characteristics are shown side by side.

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### Light vs Heat

Theoretical maximum efficacy is where 100% of electrical energy is converted into light.

Incandescent lamps turns only about 7% of electricity into light.

LED turns about 50% of electricity into light.

Increased efficiency in lighting significantly reduces cost and environmental harm of both lighting and air conditioning.

Building codes regulate lighting efficiency by specifying maximum number of lighting watts permitted per square foot of floor area.

*(Source: Heating, Cooling, Lighting by Lechner)*

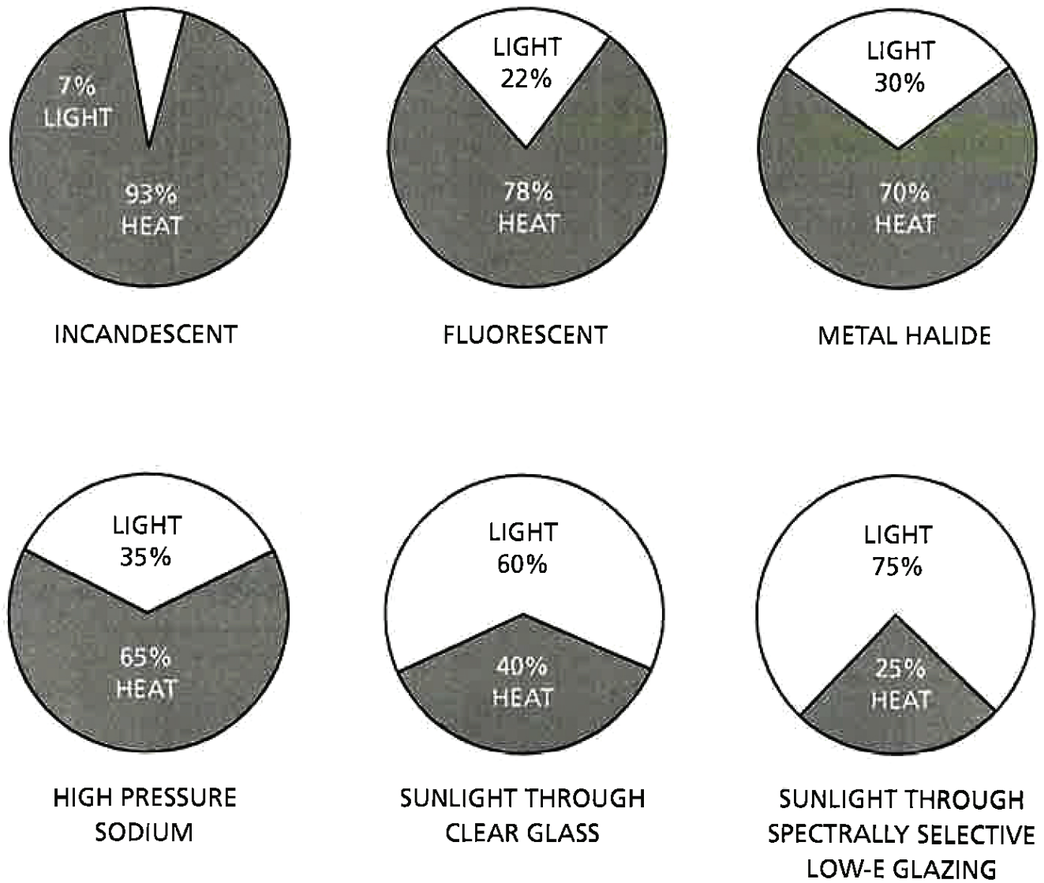


**Figure 16.2c** These pie charts show how much of the electrical energy is converted into light and how much is converted directly into heat. Clearly, the incandescent lamp is a very hot and inefficient light source since only 7 percent of the electricity is converted into light. Compact fluorescent lamps (CFL) are more than 5 times better than incandescent lamps, and linear fluorescent and LED lamps are about 8 times better.

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### Incandescent and Halogen Lamps

Incandescent

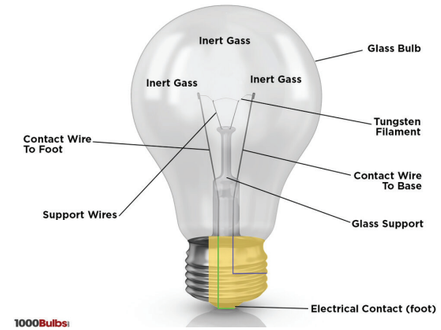
- Low efficiency
- Low bulb life
- Heat a tungsten filament until white hot (*Tungsten is a greyish-white lustrous metal, which is a solid at room temperature. Tungsten has the highest melting point and lowest vapor pressure of all metals.*)
- Wear out as the tungsten filament evaporates, becoming thinner and eventually breaking.
- Evaporation of filament can be reduced by adding halogen elements to the inert gases inside the lamp.

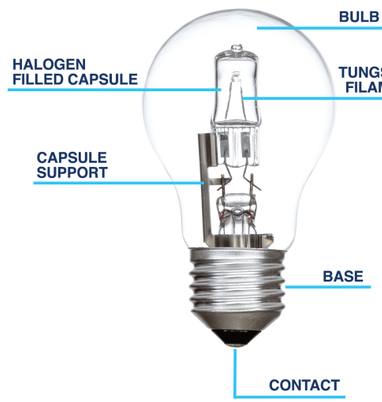
Halogen (also - tungsten halogen, quartz iodine)

- Halogen lamps are variations of incandescents. Their bulbs are made of quartz, and they can contain inert gases such as fluorine, chlorine, bromine and iodine, called halogen elements.
- Can be operated at higher temperatures without shortening lamp life excessively.
- Slightly better efficacy than incandescent
- Advantage of optical control (beam control)

*Because tungsten evaporates during the heating process, an inert gas like argon is needed to contain the tungsten and bounces the atoms back toward the filament to keep it from spreading and coating the inside of the bulb.*

*(Source: Heating, Cooling, Lighting by Lechner)*



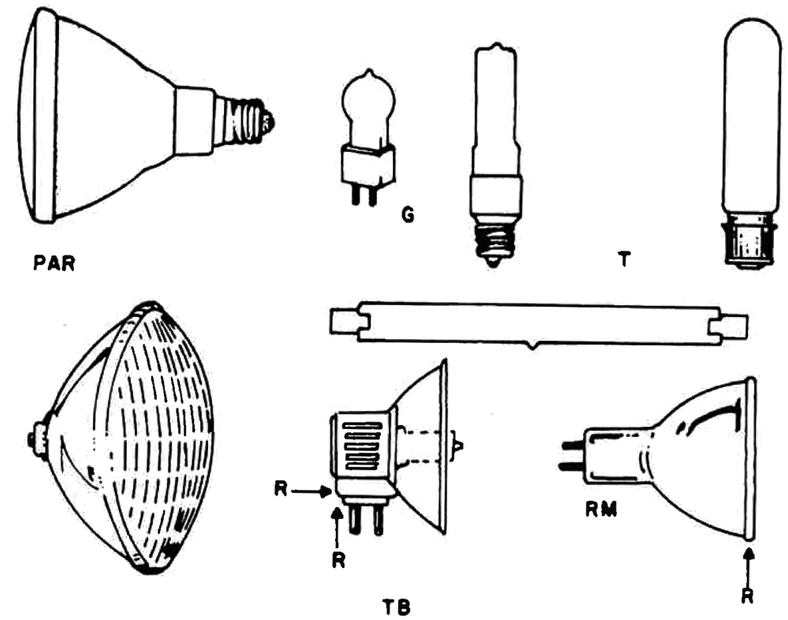




**Figure 16.3b** Common shapes of tungsten halogen lamps. (Courtesy of Osram Sylvania.)

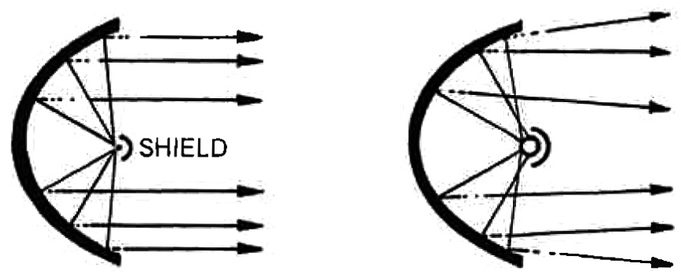



**Figure 16.3c** Parabolic reflectors will reflect light as a parallel beam if a point source is located at the focal point. Since all real sources are larger than a point, lamps cannot generate completely parallel beams of light.

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## Lighting

### Discharge Lamps

Based on phenomenon known as *discharge*, in which an ionized gas rather than a glowing hot tungsten filament emits light.

- Require a ballast that ignites the lamp with a high voltage and then limits the electric current to the proper operating level.
- High efficacy
- Long life
- Some have the liability of using the toxic element mercury

Few types: Fluorescent, Neon, HID

*Ionize: to dissociate atoms or molecules into electrically charged.*

*Note: the ballast regulates the current to the lamps and provides sufficient voltage to start the lamps. Without a ballast to limit its current, a fluorescent lamp connected directly to a high voltage power source would rapidly and uncontrollably increase its current draw.*

*(Source: Heating, Cooling, Lighting by Lechner)*

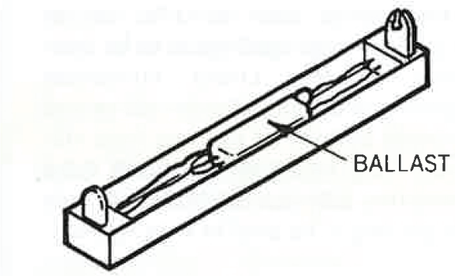



**Figure 16.4** All discharge lamps require a ballast first to start the lamp and then to maintain the proper operating current.

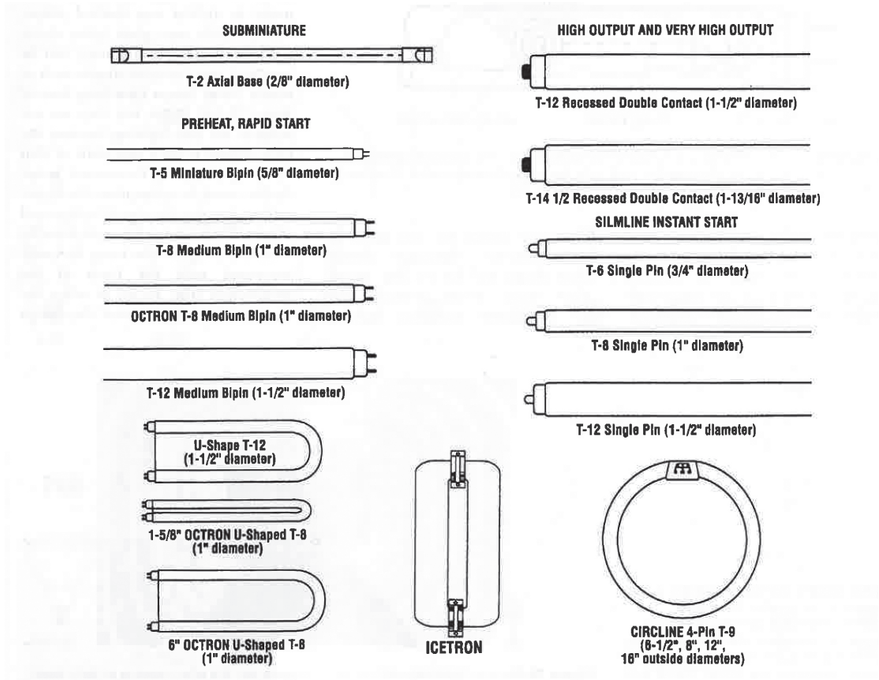
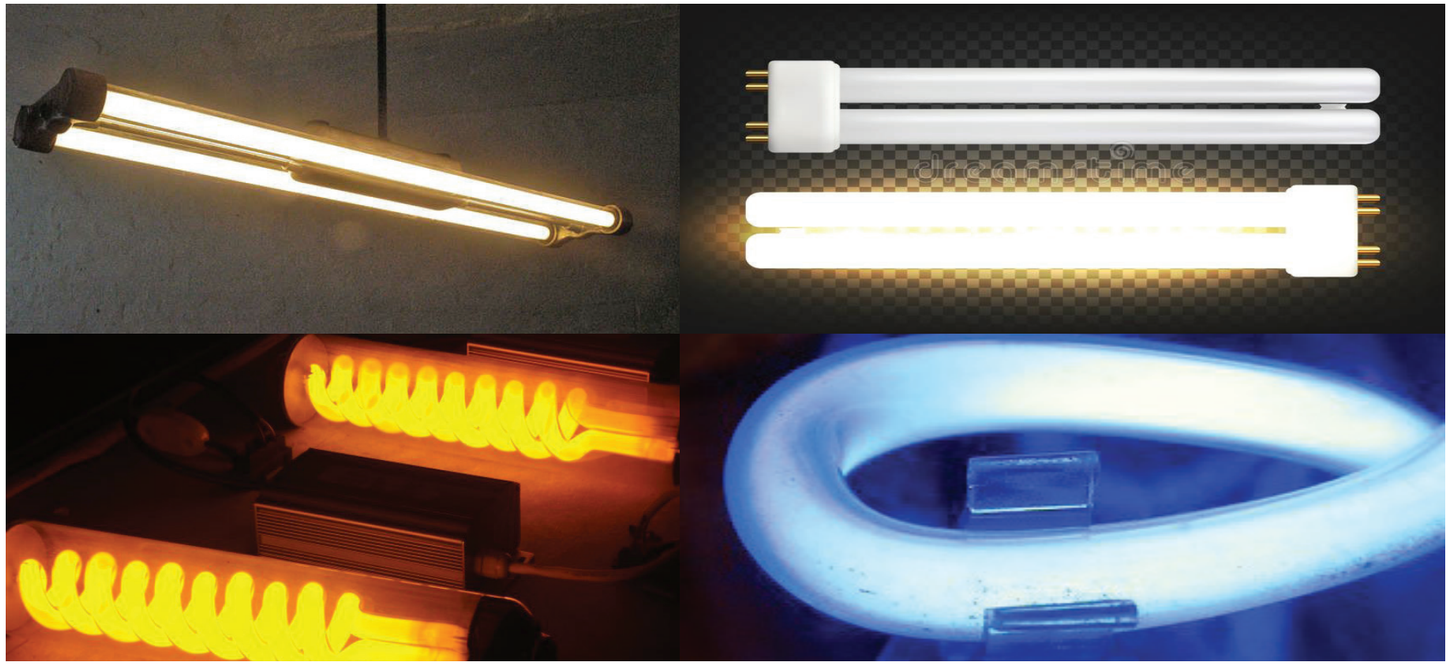



**Figure 16.5a** Common shapes and sizes of fluorescent lamps. (Courtesy of Osram Sylvania.)



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## Lighting

### Fluorescent

- Radiation is emitted from a low-pressure mercury vapor that is ionized.
- Since much of the radiation is in the ultraviolet part of the spectrum, the inside surface of the glass tube is coated with phosphors to convert the invisible radiation into light.
- By using different phosphors, can be designed to emit various types of white light.
- Available in variety of sizes, colors, wattages and shapes.
- Because light is emitted from the surface of the glass bulb rather than from a point-like source, fluorescent lamps are not good for beam control.
- Best used for area lighting
- Popular for offices and schools because of high efficacy, long life and good color rendition.

*Phosphors: material that emits light, or luminescence, when exposed to radiation such as ultraviolet light or an electron beam.*

*(Source: Heating, Cooling, Lighting by Lechner)*

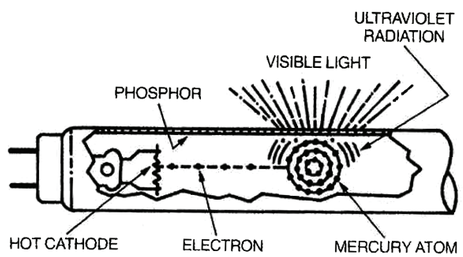
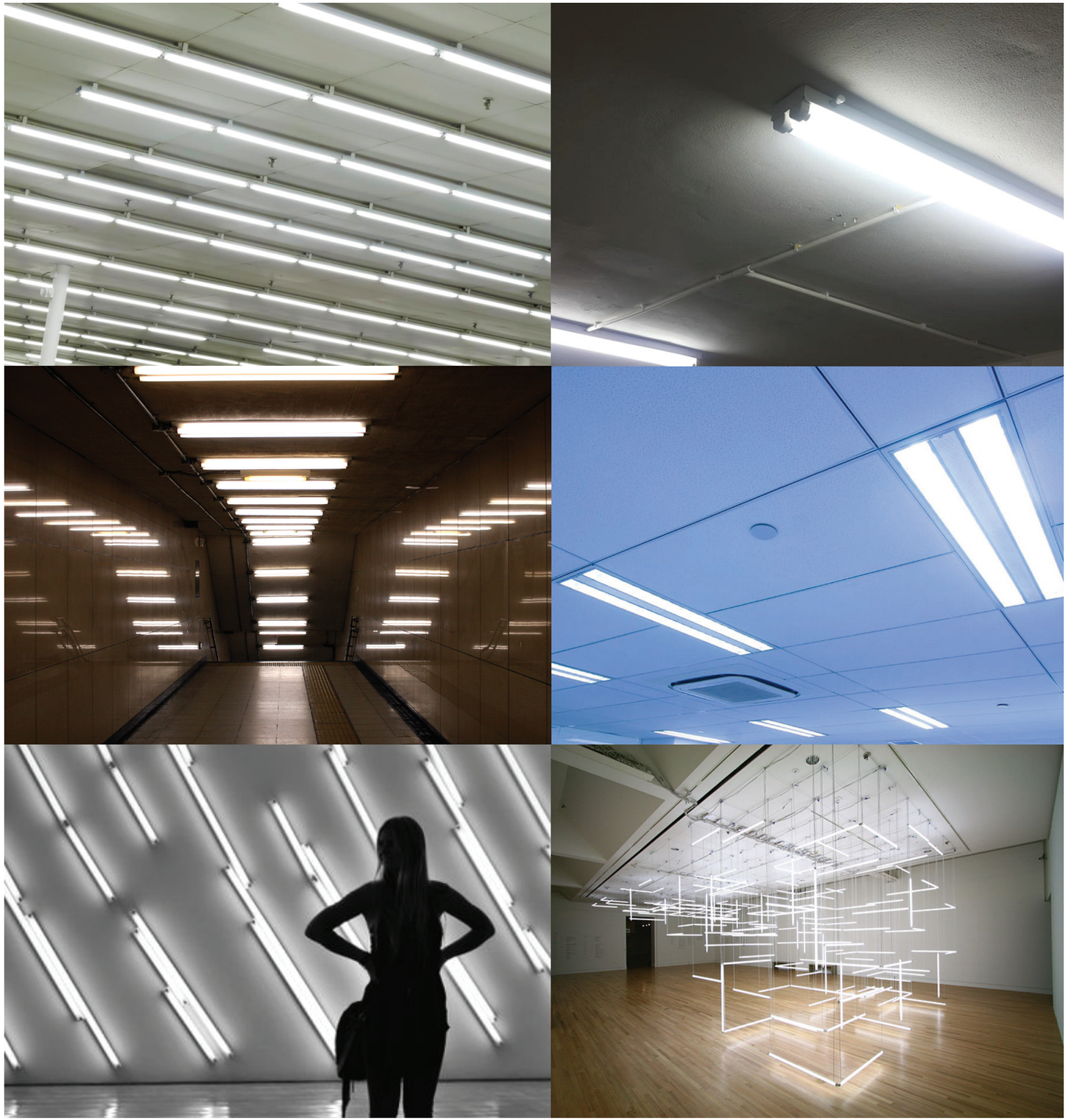



**Figure 16.5c** The basic features of a fluorescent lamp are shown. The ultraviolet radiation is converted into visible light by the phosphor coating on the inside of the glass tube. (Courtesy of GTE Products Corporation, Sylvania Lighting Center.)



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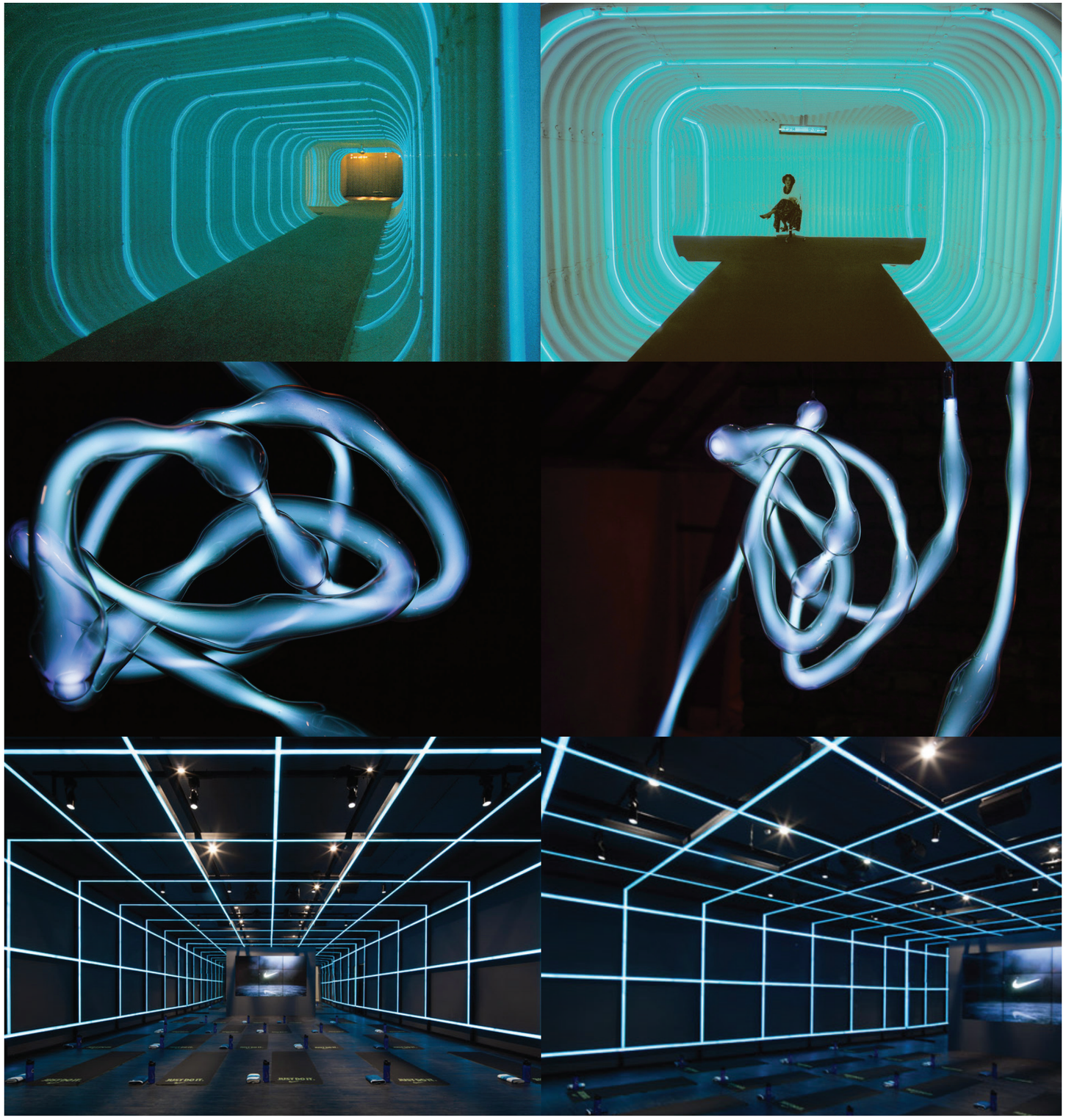
## Lighting

### Neon

- Use gases such as neon, which gives off red light and argon, which gives off blue light.
- Through the use of different combinations of gases, colored glass, and phosphors a large variety of colored light sources is possible.
- Can be custom made to almost any desired shape.
- Long life (about 25,000 hours)
- Not suitable for area lighting (output is only one-sixth of equally long fluorescent lamp)
- Good for when shape of lamp is closely integrated with the form or when shape of lamp is itself the design

Images
- 127 John Street, Neon Tunnel, NYC, 1971
- Amsterdam designer Pieke Bergmans (blown glass and neon)
- Coordination Asia uses neon grids to transform a Beijing art gallery into a gym for Nike

*(Source: Heating, Cooling, Lighting by Lechner)*



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## Lighting

### High-Intensity Discharge (HID)

- Very efficient
- Size and shape similar to incandescent
- Need a ballast
- Light emitted from small arc tube located inside a protective bulb
- Offer some optical control
- Require a few minutes to reach maximum light output

*(Source: Heating, Cooling, Lighting by Lechner)*

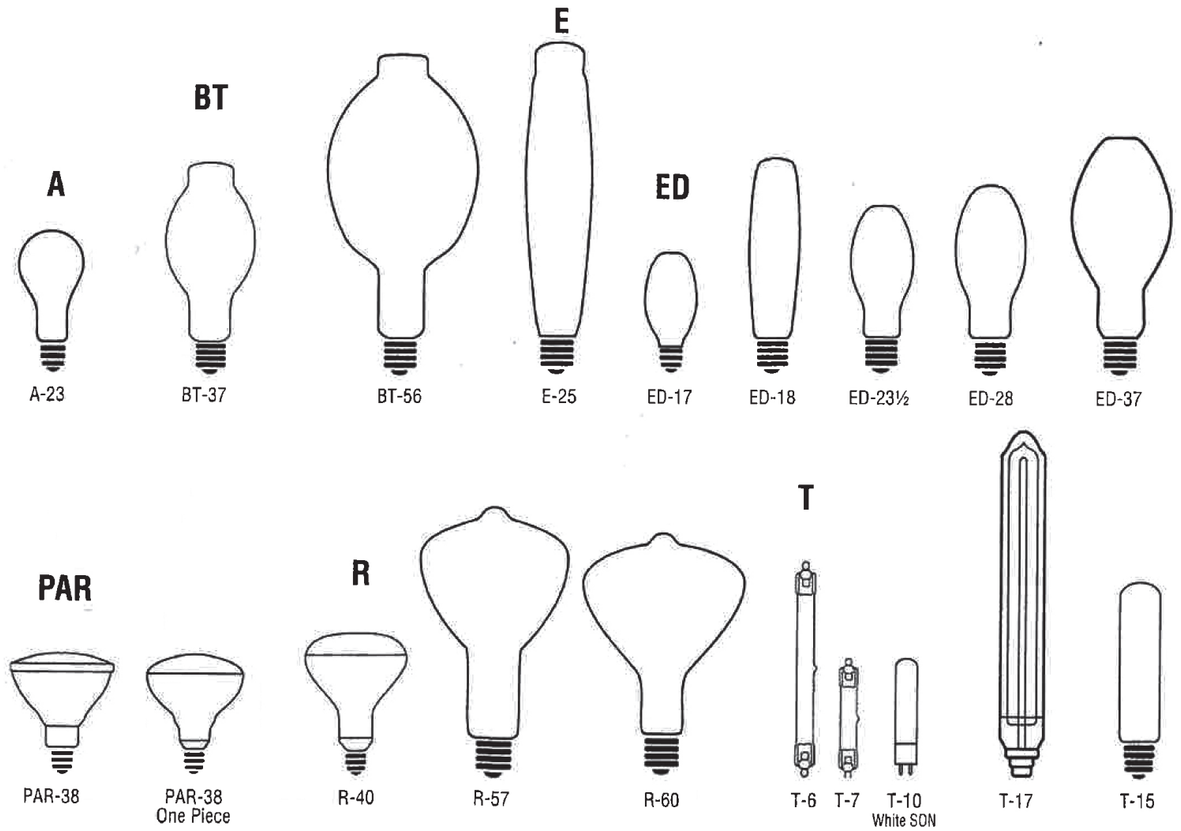


**Figure 16.6a** The common shapes of high-intensity discharge (HID) lamps. (Courtesy of Philips Lighting.)

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## Lighting

### Light Emitting Diodes (LED)

- Main light source from a larger group called solid-state lighting (SSL).
- Are semiconductor devices that convert electrical energy into light energy.
- Light is emitted from the top of a chip and waste heat is emitted from the back through a heat sink
- Very efficient
- Long life
- Small size and flexibility
- Ideal sources for applications where spot or narrow beams area required
- Need a power supply often called a “driver”
- Very sensitive to heat and therefore need to be designed to dissipate heat (heat sink)
- Benefit to the environment and often promoted by governments and utility companies (main benefit is energy efficiency)

LED Linear - https://www.ledlinearusa.com/

*(Source: Heating, Cooling, Lighting by Lechner)*

*Note: SSL - https://en.wikipedia.org/wiki/Solid-state_lighting*
*Semiconductor - A semiconductor is a material that has an electrical conductivity value falling between that of a conductor, such as copper, and an insulator, such as glass.*

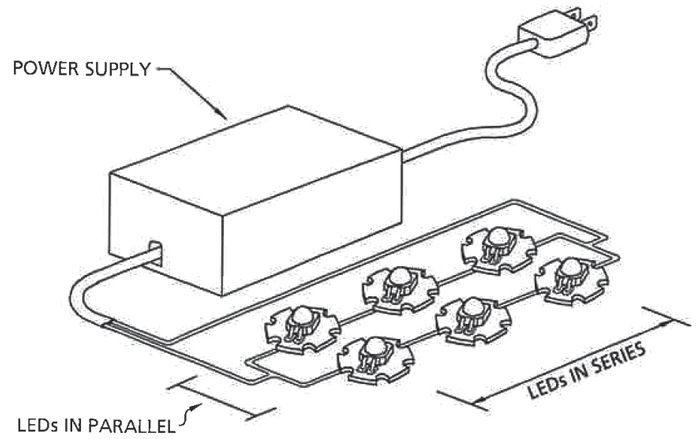


**Figure 16.7b** Because LEDs are small, most applications use many of them in one lamp/fixture. They are connected to a power supply (driver) either in series or parallel.

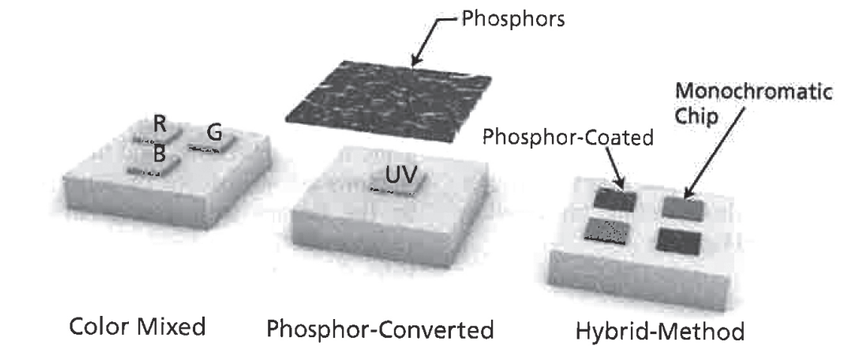


**Figure 16.7c** Most LEDs use one of these three methods to generate white light: (1) color-mixed, (2) phosphor-converted, and (3) hybrid method.

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## Lighting

### Organic Light Emitting Diodes (OLED)

Area sources that come in very thin flexible sheets, which emit diffuse light.

*(Source: Heating, Cooling, Lighting by Lechner)*

*OLED - https://en.wikipedia.org/wiki/OLED*

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## Lighting

### Luminaires / Lighting Fixtures

Four major functions

- Support lamp with some kind of socket
- Supplying power to the lamp
- Modifying the light from the lamp to achieve a desired light pattern
- Reduce glare

Divided into 6 generic categories by the way they distribute light

- Direct
- Semi-direct
- General diffuse
- Direct-indirect
- Semi-indirect
- Indirect

Distribution of light often defined by a curve on a polar-co-ordinate graph where distance from center represents the candlepower (candelas) in that direction.

ERCO (Jilly Specs and download)

https://www.erco.com/en/products/indoor/pendant-luminaires/jilly-linear-6914/#articles?specsheet=50675.000

*(Source: Heating, Cooling, Lighting by Lechner)*

**Table 16.3 Lighting Fixtures (Luminaires)**

| Illustration | Distribution of Light (% directed up/% directed down) | Type |
|---|---|---|
|  | 0–10<br>90–100 | *Direct:* Direct lighting fixtures send most of the light down to the workplane. Since little light is absorbed by the ceiling or walls, this is an efficient way to achieve high illumination on the workplane. Direct glare and veiling reflections are often a problem, however. Also, shadows on the task are a problem when the fixture-to-fixture spacing is too large. |
|  | 10–40<br>60–90 | *Semidirect:* Semidirect fixtures are very similar to direct luminaires except that a small amount of light is sent up to reflect off the ceiling. Since this creates some diffused light as well as a brighter ceiling, both shadows and the apparent brightness of the fixtures are reduced. Veiling reflections can still be a problem, however. |
|  | 40–60<br>40–60 | *General diffuse:* This type of fixture distributes the light more or less equally in all directions. The horizontal component can cause severe direct glare unless the diffusing element is large and a low-wattage lamp is used. |
|  | 40–60<br>40–60 | *Direct-indirect:* This luminaire distributes the light about equally up and down. Since there is little light in the horizontal direction, direct glare is not a severe problem. The large indirect component also minimizes shadows and veiling reflections. |
|  | 60–90<br>10–40 | *Semi-indirect:* This fixture type reflects much of the light off the ceiling and, thus, yields high-quality lighting. The efficiency is reduced, however, especially when the ceiling and walls are not of a high-reflectance white. |
|  | 90–100<br>0–10 | *Indirect:* Almost all of the light is directed up to the ceiling in this fixture type. Therefore, ceiling and wall reflectance factors must be as high as possible. The very diffused lighting eliminates almost all direct glare, veiling reflections, and shadows. The resultant condition is often used for ambient lighting. |

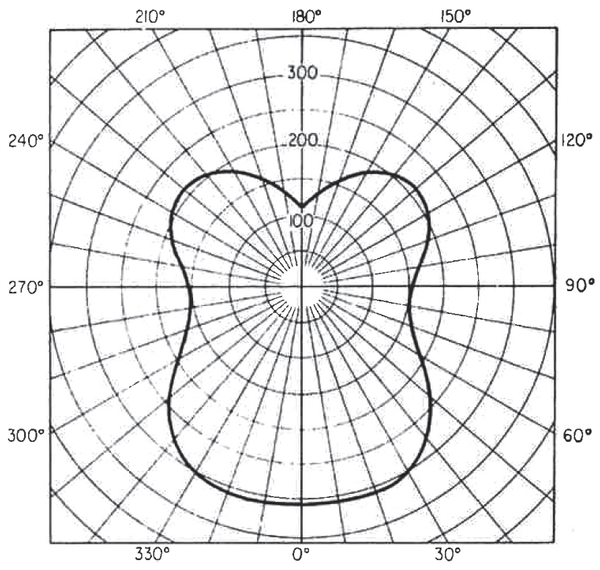


**Figure 16.8a** Manufacturers generally supply candlepower (candela) distribution curves for their lighting fixtures. In this vertical section, the distance from the center determines the intensity of the light in that direction. This curve is for a semidirect lighting fixture.(Courtesy of Osram Sylvania.)

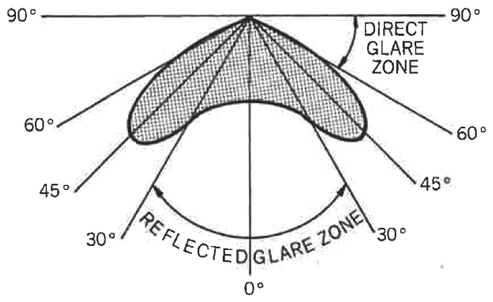


**Figure 16.8b** For luminaires that have no uplight, only the bottom half of the polar coordinate graph is shown. Light that leaves the luminaire from the 0 to 30° zone tends to cause veiling reflections and reflected glare, while light in the 60 to 90° zone tends to cause direct glare. Fixtures with batwing light-distribution patterns yield a better-quality light because they minimize the light output in these problematic zones. However, they are not ideal when computers are used, because they were designed for tasks on horizontal surfaces.

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## Lighting

### Baffles, Louvers, and Eggcrate Devices

Devices that limit glare by restricting the angle at which light leaves the luminaire.

Can be small and part of the luminaire or large and part of the architecture.

*(Source: Heating, Cooling, Lighting by Lechner)*

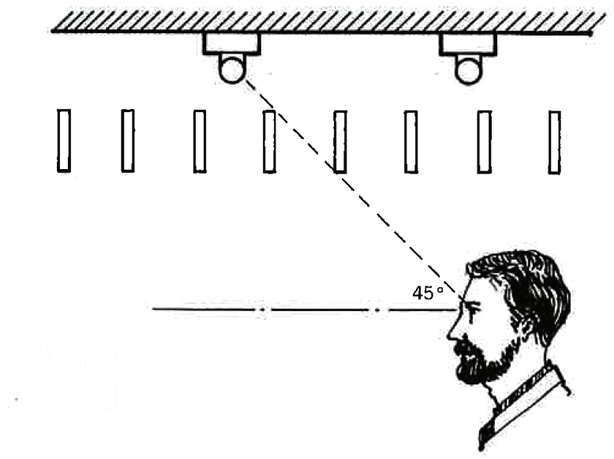
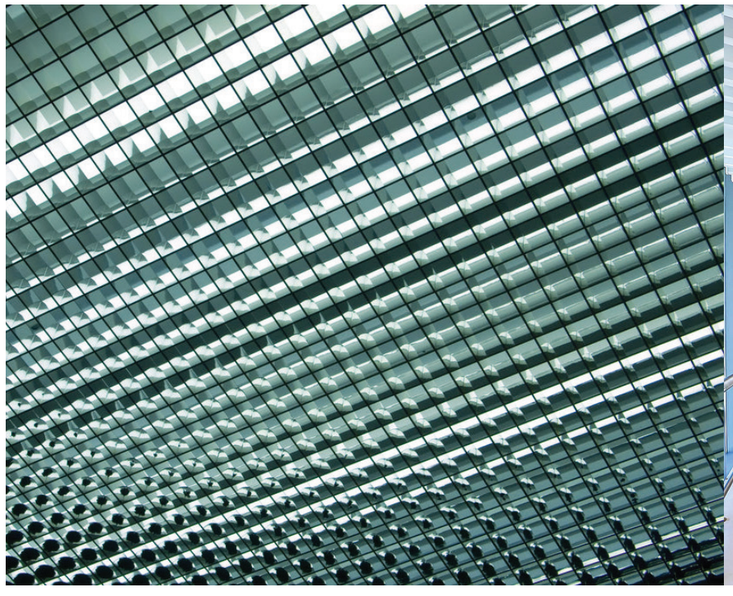



**Figure 16.8d** Baffles, louvers, and eggcrates are used to shield against direct glare. The direct view of the lamps should be shielded up to at least 45°.



Eggcrate Ceiling

Baffle Ceiling

**Parabolic Louvers**

Parabolic wedges with specular finish

- Extremely effective in preventing direct glare because the light distributed is almost straight down
- High visual comfort probability (VCP)
- Good at preventing veiling reflections (computer monitors, etc.)

*(Source: Heating, Cooling, Lighting by Lechner)*

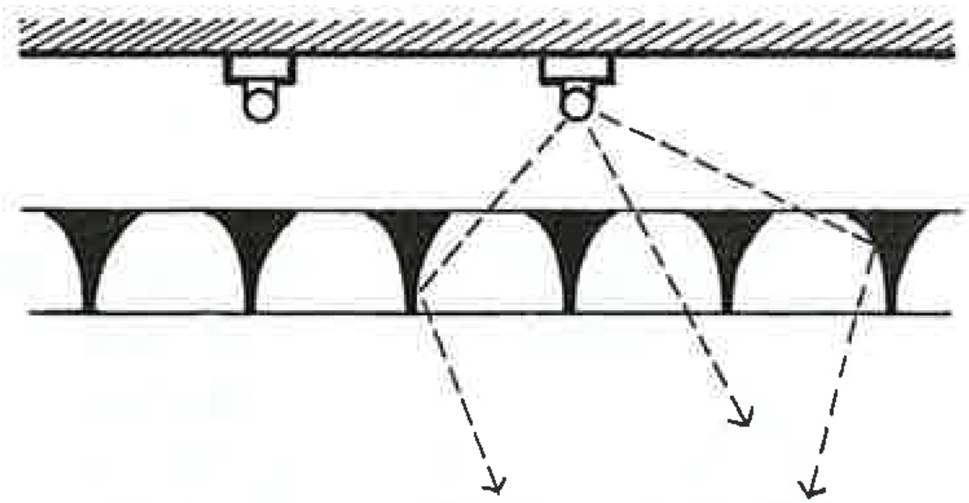


**Figure 16.8f** Parabolic louvers are very effective in reducing direct glare and veiling reflections on vertical surfaces such as computer screens.

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## Lighting

### Diffusing Glass or Plastic

Translucent or surface-frosted sheets diffuse the emitted light more or less equally in all directions

*(Source: Heating, Cooling, Lighting by Lechner)*

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## Lighting

### Lenses and Prisms on Clear Sheets

Surface of clear sheets formed into small lenses or prisms

- Good optical control possible
- Light is refracted so that more of the distribution is down and direct glare reduced
- Round fixtures can use Fresnel lenses that can either concentrate the light or disperse the light

*(Source: Heating, Cooling, Lighting by Lechner)*

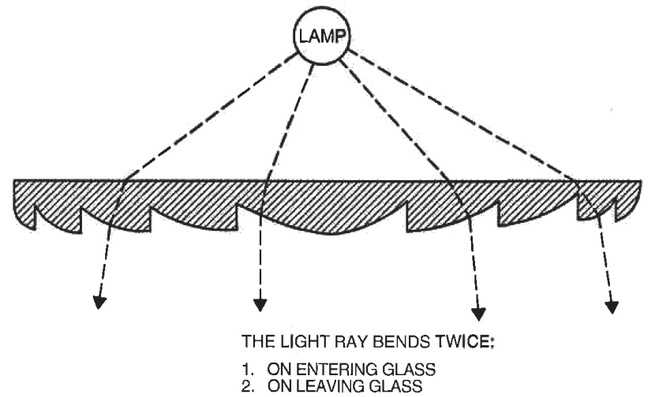
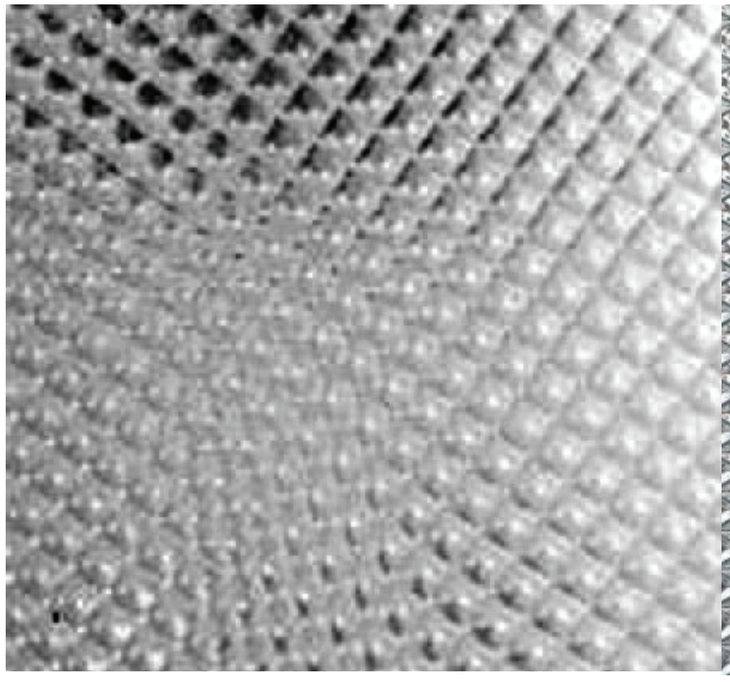
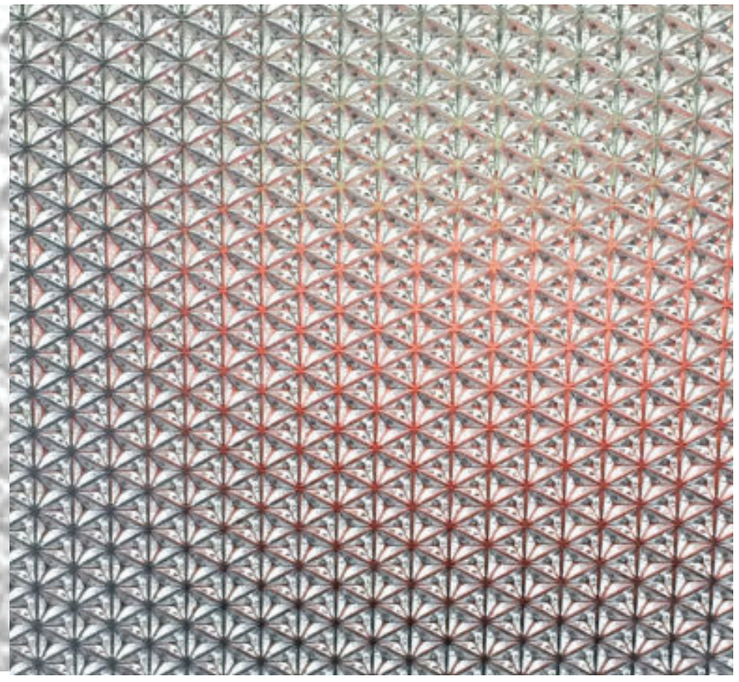



**Figure 16.8h** Lenses and prisms refract light down to reduce direct glare. Fresnel lenses are made of thin plates but act as if they were thick convex or concave lenses. The light bends twice: on entering and on leaving the lens.





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## Lighting

### Lighting Systems

General lighting

- Usually consists of more or less uniformly spaced, ceiling-mounted direct lighting fixtures.
- Flexibility in arranging and rearranging work areas due to overall even lighting
- Low energy efficiency because noncritical work areas receive as much light as task areas

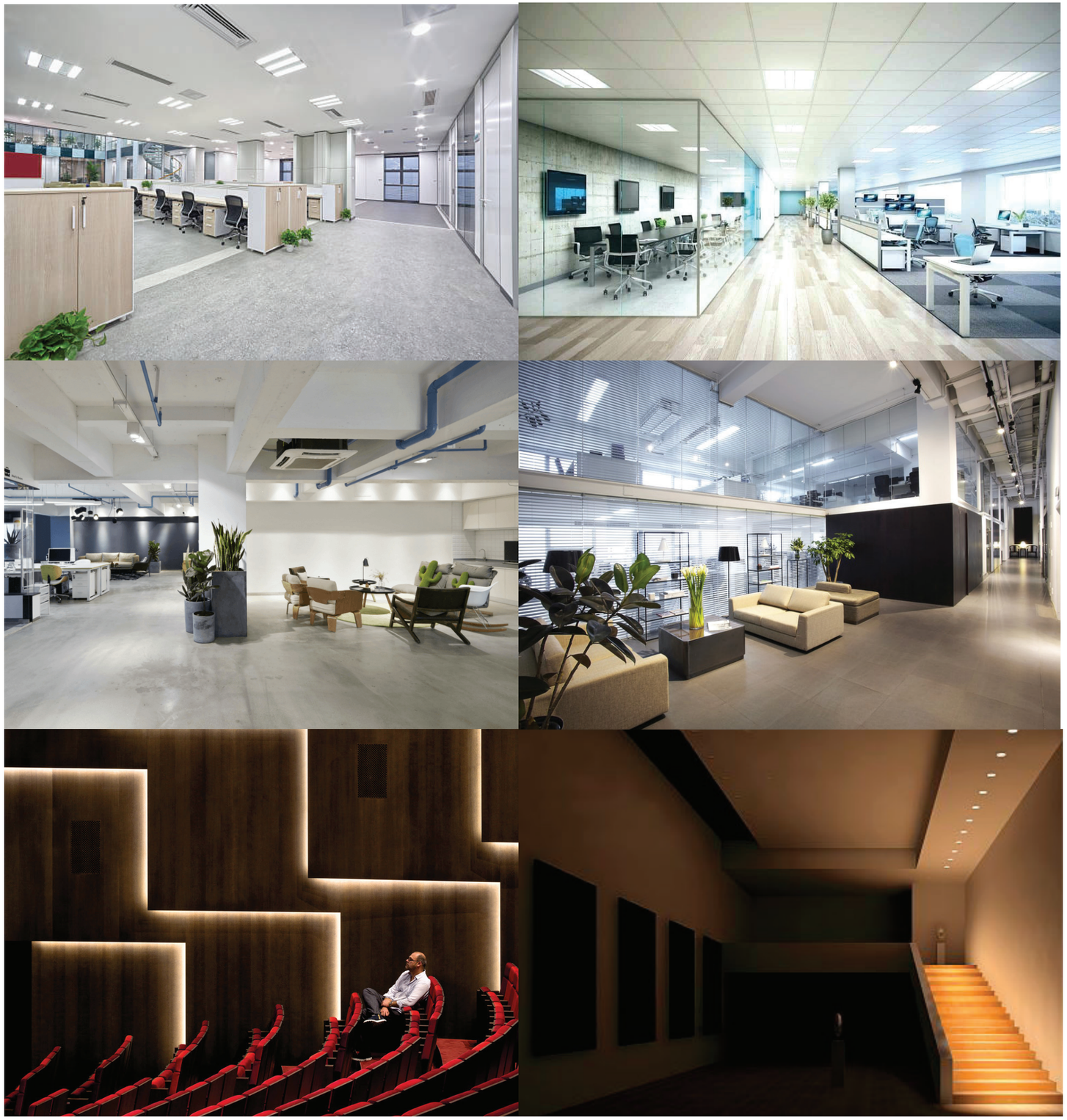
Localized Lighting

- Nonuniform arrangement in which lighting fixtures are concentrated over work areas
- Fairly high efficiency (non work areas are not illuminated to the same degree as work areas)

Accent Lighting

- Whenever an object or part of a building is to be highlighted
- Should be about ten times higher than the surrounding light level

*(Source: Heating, Cooling, Lighting by Lechner)*



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## Lighting

### Lighting Systems

Ambient Lighting

- Indirect lighting reflected off the ceiling and walls.
- Diffused, low-illumination level lighting that is sufficient for easy visual tasks and circulation
- Usually used in conjunction with task lighting and then known as task/ambient lighting
- Direct glare and veiling reflections can be almost completely avoided with this approach.

Task Lighting

- High flexibility, quality, and energy efficiency
- Individual control possible with personal lighting systems offers psychological benefits

Task/Ambient

- Luminaires often required to complement task lighting
- Most sustainable by using less energy and usually high-quality lighting

*(Source: Heating, Cooling, Lighting by Lechner)*

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## Lighting

### Visualizing Light Distribution

Point Source - Illumination is inversely proportional to the square of the distance.

Line Source - Illumination is inversely proportional to the distance.

Surface Source - Illumination does not vary with distance.

*(Source: Heating, Cooling, Lighting by Lechner)*

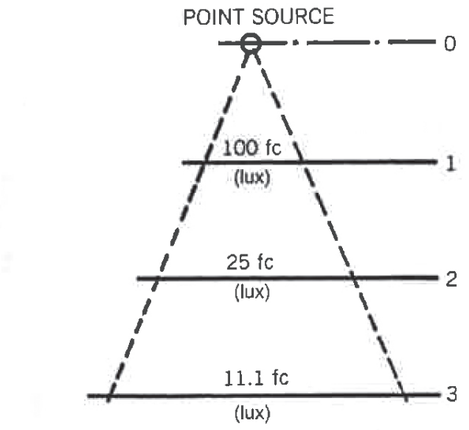


**Figure 16.10a** The illumination from a point source is inversely proportional to the square of the distance (feet, meters, or any other unit).

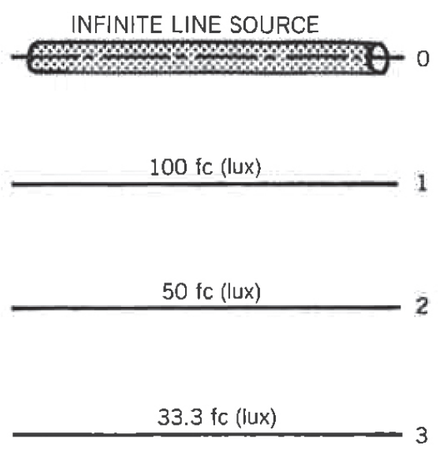


**Figure 16.10b** The illumination from a line source of infinite length is inversely proportional to the distance.

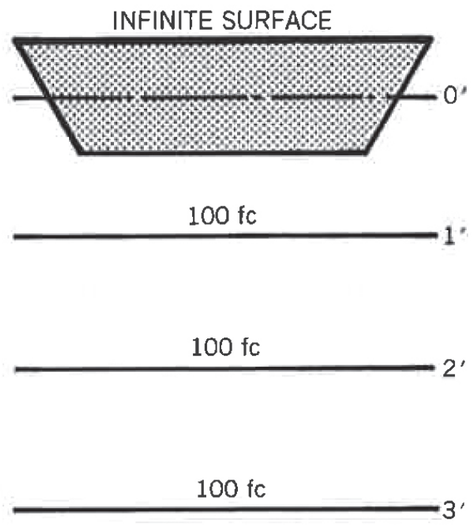


**Figure 16.10c** The illumination from a surface of infinite area is constant with distance.

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## Lighting

### Visualizing Light Distribution

Graphing Illumination

A. Using points of equal illumination to plot contour lines of the light pattern in plan (isofootcandle (isolux) lines)

B. Graph of the light distribution superimposed on a section of the space.

*(Source: Heating, Cooling, Lighting by Lechner)*

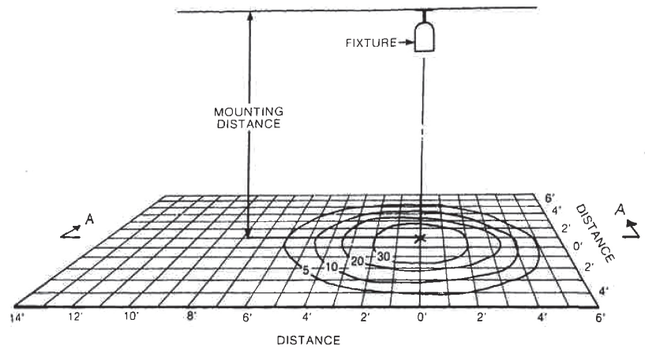


**Figure 16.10d** This graphic presentation of the illumination pattern in plan is generated from isofootcandle (isolux) lines connecting points of equal illumination. (Courtesy of Cooper Lighting.)

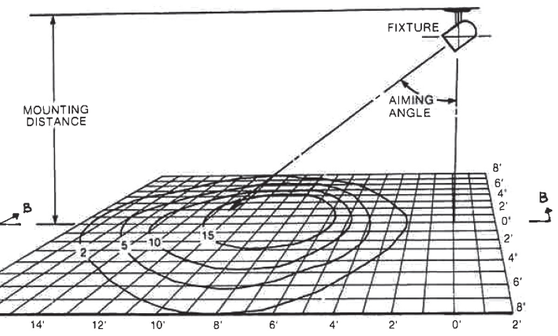


**Figure 16.10e** When light is not aimed straight at a surface, the isofootcandle (isolux) lines are elongated. The lines are now of reduced intensity but cover a larger area. (Courtesy of Cooper Lighting.)

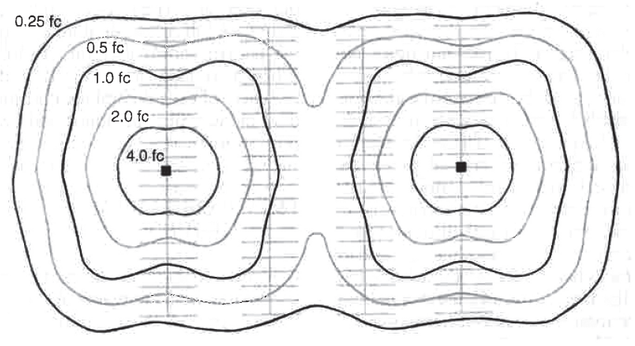


**Figure 16.10f** Isofootcandle (isolux) lines used to define the lighting pattern from a parking-lot lighting design. (Courtesy of Spaulding Lighting, Inc.)

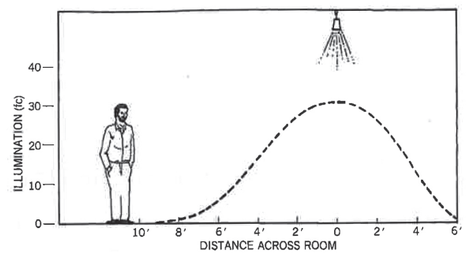


**Figure 16.10g** In this alternate graphic method of defining the lighting pattern, a curve of the illumination across a room is plotted on top of a section of the space. This diagram, in fact, is section A–A of the room in Figure 16.10d.

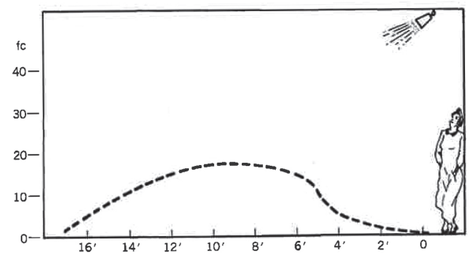


**Figure 16.10h** This diagram plots the illumination across the room at section B–B of Figure 16.10e. Again, we can see that when the light source is not aimed normal (perpendicular) to the workplane, the maximum illumination is reduced and the light is spread over a larger area.

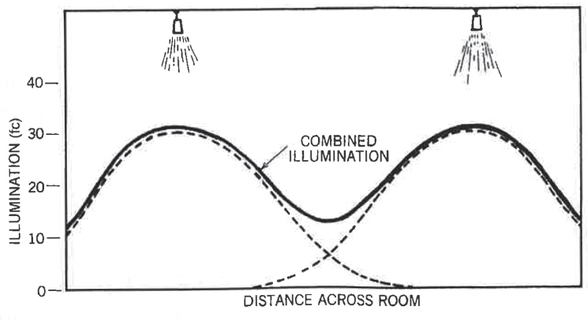


**Figure 16.10i** When more than one light source is present, the curve defining the combined effect is the sum of the individual curves.

# ARC 3723 | EBS II

## Lighting

### Architectural Lighting

Cove Lighting

- Indirect lighting of the ceiling from continuous wall-mounted fixtures
- Soft, diffused ambient light
- Creates feeling of spaciousness
- Placed high enough so out of direct view
- Far enough from the ceiling to avoid excessive brightness (hot spots)

Coffer Lighting

- Pockets in the ceiling that can be illuminated on variety of ways

*(Source: Heating, Cooling, Lighting by Lechner)*

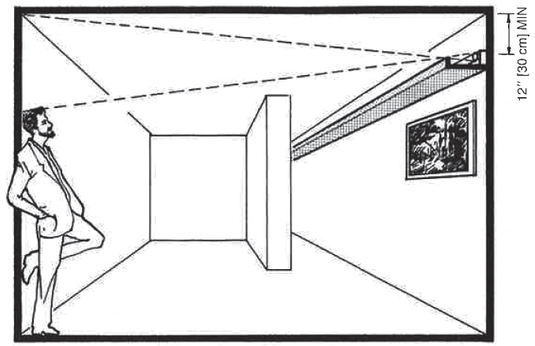


**Figure 16.11a** Ceilings appear to recede with cove lighting. Lamps must be shielded from view.

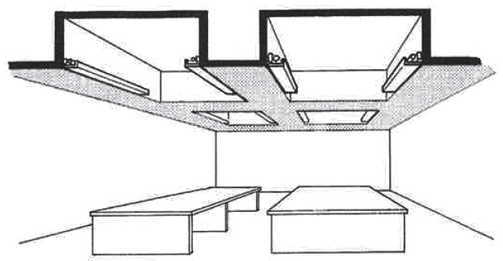

**Figure 16.11b** Large coffers can be illuminated with cove lighting.

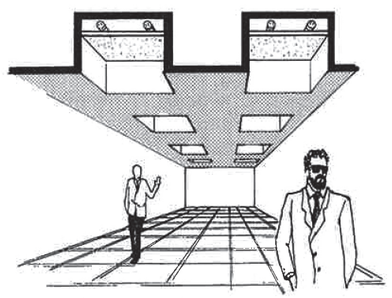

**Figure 16.11c** Small coffers can be illuminated by direct luminaires in each coffer.

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## Lighting

### Architectural Lighting

Luminous-Ceiling Lighting

- Provides large areas source of uniform illumination by means of continuous diffuser elements suspended below uniformly placed lamps (typically fluorescent).

*(Source: Heating, Cooling, Lighting by Lechner)*

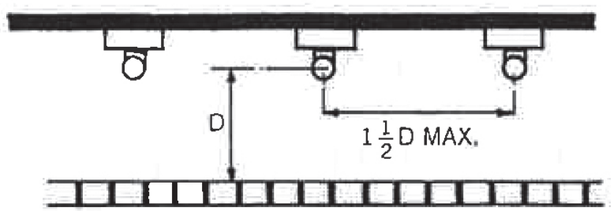
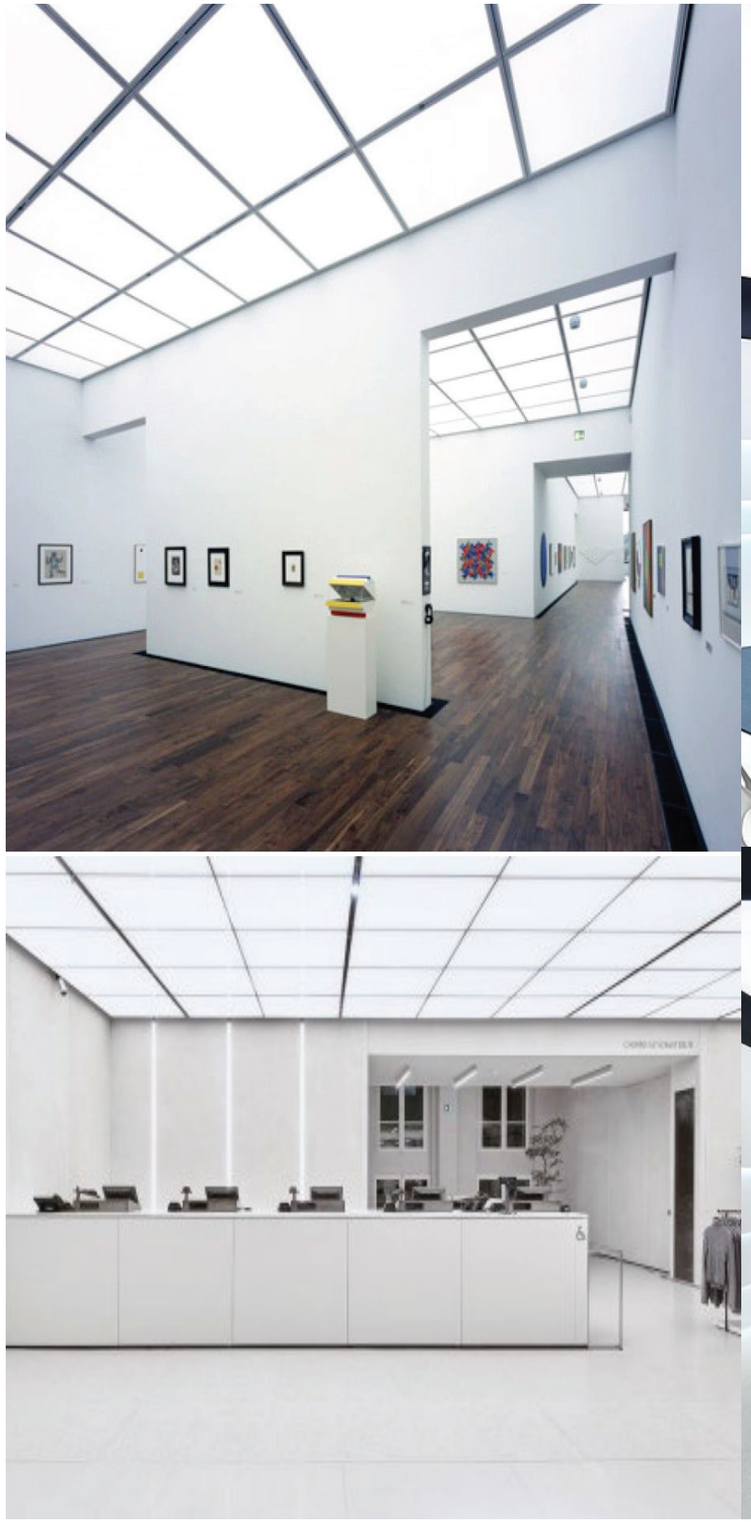



**Figure 16.11d** The very even brightness of luminous ceilings can create difficulties. Not only is it technically difficult to achieve and maintain, but it also tends to simulate a gloomy overcast sky.



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## Lighting

### Architectural Lighting

Wall Illumination - Lighting fixtures mounted on the ceiling or walls can increase the brightness of the walls, emphasize texture, or accent certain features.

Valance (Bracket) Lighting

- Illuminates the wall both above and below the shielding board.

Cornice (Soffit) Lighting

- Valance board moved up to the ceiling
- Wall only illuminated from above
- Ceiling receives no light

*(Source: Heating, Cooling, Lighting by Lechner)*

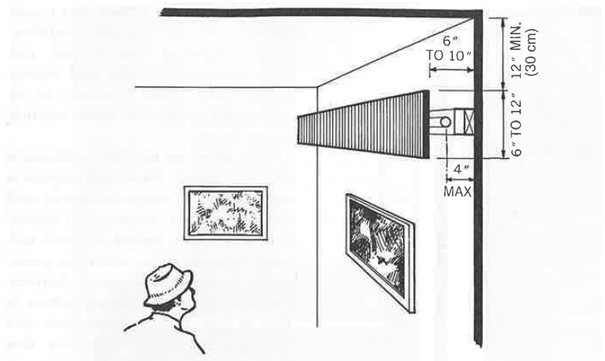



**Figure 16.11e** Valance lighting can increase the wall brightness, which is very important in the overall visual appearance of a space. The specific design of a valance depends greatly on the expected viewing angles in a particular room.

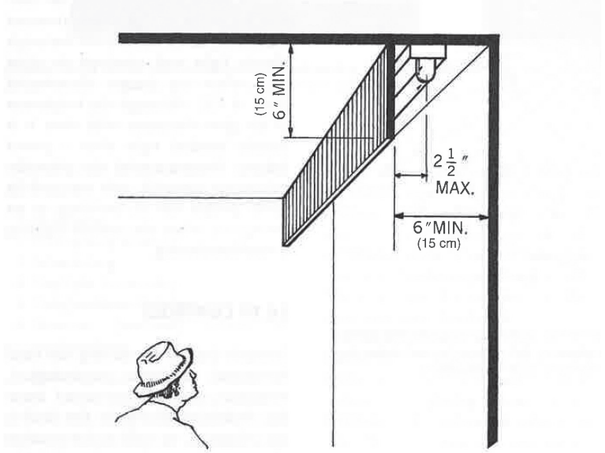



**Figure 16.11f** Because cornice lighting illuminates only the walls and not the ceiling, excessive brightness ratios can occur.

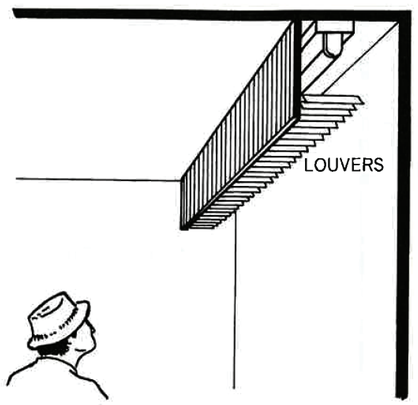
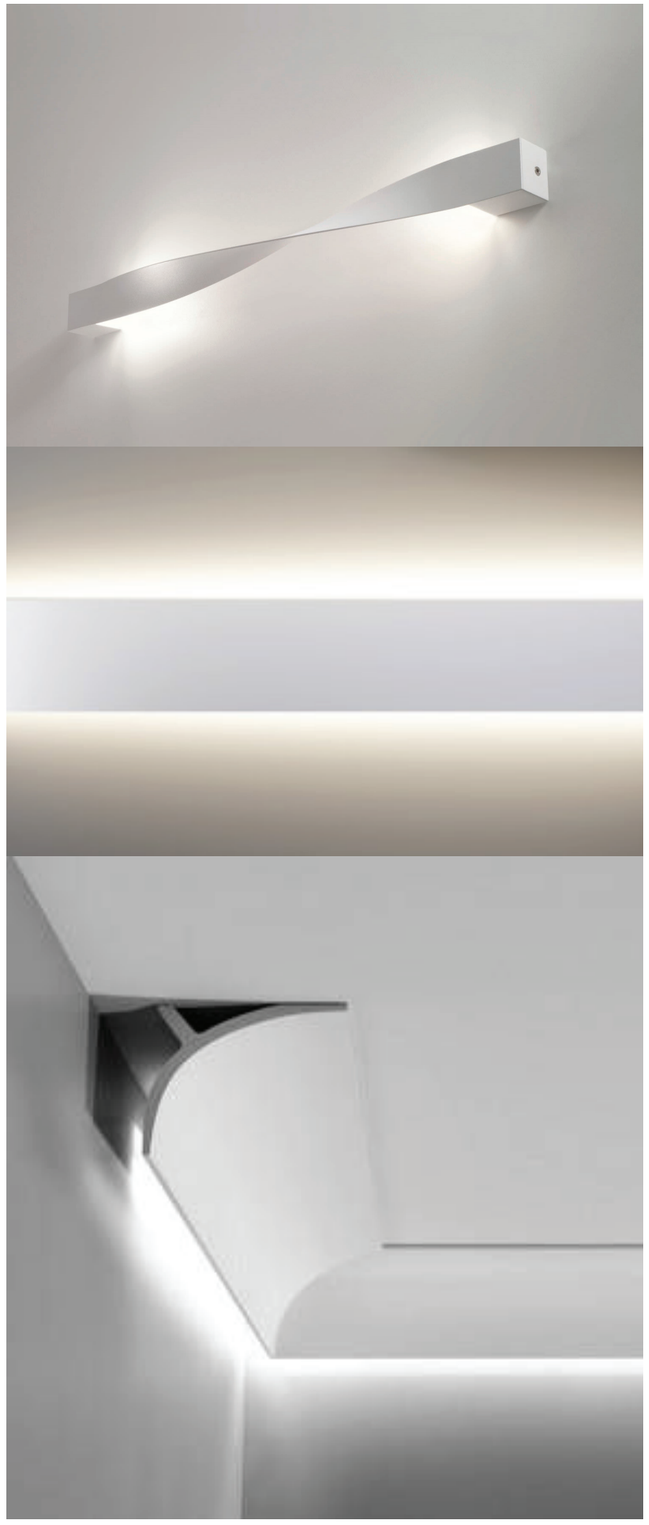



**Figure 16.11g** In some cases, the viewing angles are such that direct glare will result unless louvers or some other shielding devices are used in the cornice.



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## Lighting

### Architectural Lighting

Louvre-Lens

The Louvre-Lens is an art museum located in Lens, France, approximately 200 kilometers north of Paris.

Architect - SANAA

ArchDaily
https://www.archdaily.com/312978/lovre-lens-sanaa

ERCO Lighting
https://www.youtube.com/watch?v=9U5CkpJi960