

PDHonline Course A129 (2 PDH)

An Introduction to Interior Lighting Design

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An Introduction to Interior Lighting Design

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1. INTRODUCTION. The IES *Lighting Handbook* defines visibility as, “the ability to extract information from the field of view.”1 Visibility is affected by glare, uniformity, illuminance, surface brightness, and lighting components. The consideration of these factors improves task performance, mood and atmosphere, visual comfort, aesthetic judgment, health, safety and well-being, and social communication. Additionally, sustainability concerns, lighting control, and maintenance issues all affect the amount of energy required to achieve, operate, and maintain this level of visibility. The *Lighting Handbook*, Chapter 10 “Quality of the Visual Environment” (“Quality of the Visual Environment”, *Lighting Handbook Reference and Application*, Chapter 10, Ninth Edition, The Illuminating Engineering Society of North America, 2000). discusses each of these aspects in detail. A lighting design guide matrix lists the critical design issues that must be followed.

2. VISIBILITY.

2.1 Task visibility describes how size, brightness, and contrast of a particular activity affect the lighting required to view that activity. The ability to actually perform a task well includes other non-visual human factors such as skills and experience, independent of the task visibility.

2.2 Large tasks generally require less illuminance, brightness, and contrast to be performed. Small detailed tasks may require task lighting to increase the light level significantly. Knowing a description of the task is essential to designing the lighting for that task. The luminance or brightness of a task increases the task visibility. Brighter tasks are easier to see, so long as it is not so much brighter than its surroundings that it becomes uncomfortable or a source of direct glare. As task contrast decreases, the light level required to see it will increase. If the contrast is too low, it will be difficult to distinguish various components of the task, reducing visibility.

2.3 Way finding refers to the visual guidance provided by the lighting system and the visual elements illuminated. This visual guidance may be illuminated signage that

directs occupants to various destinations, or it may be more subtle aids such as continuity and hierarchy of lighting equipment that reinforces areas of similar use. By using the same luminaires for areas of the same use, a consistent pattern is established that visually guides and orients building occupants. Accent lighting can also be used to draw attention to specific areas by increasing the brightness.

2.4 In exterior applications, the size and type of lighting equipment provides visual cues about the surroundings. Bollards and low pedestrian scale poles often signify pedestrian walkways or plazas. Roadway poles may alert pedestrians to intersections in the same way that pedestrian poles or bollards may alert motorists to crosswalks.

3. GLARE.

3.1 Direct glare is caused by excessive light entering the eye from a bright light source. The potential for direct glare exists anytime one can “see” a light source. With direct glare, the eye has a harder time seeing contrast and details. A system designed solely on lighting levels, tends to aim more light directly towards a task, thus producing more potential for glare. The effective use of indirect light minimizes the negative effects of direct glare. In some circumstances such as entries and checkpoints, glare can be used to increase vertical illuminance on approaching vehicles or individuals while increasing visibility for guards and patrols.

3.1.1 Causes of direct glare include an exposed bright light source, for example an HID high bay luminaire, or an exterior floodlight. Overhead T5HO fluorescent lamps in a downlight also can cause direct glare.

3.1.2 Direct glare can be minimized with careful equipment selection and placement. In interior applications, indirectly light the walls and ceiling. A limited amount of direct light can provide accent and task lighting. In exterior applications, use fully shielded luminaires that directs light downwards towards the ground or a building façade.

3.2 Indirect or reflected glare is caused by light reflecting off the task or pavement in such a manner that the contrast is “washed out”. Many work situations position the light directly in front of the task, producing reflected glare. Unshielded streetlights can also produce reflected glare on wet pavement, washing out lines on the road. Reflected glare will limit one’s ability to “see” contrast.

3.2.1 Like direct glare, indirect glare can be minimized with the type and layout of lighting equipment. For interior applications, locate direct light to the side or behind a critical task. Use semi-indirect light to bounce light off of surfaces in order to provide uniform low glare light with less reflected glare. For exterior lighting, direct the light away from the observer with the use of low glare, fully shielded luminaires.

3.3 Overhead glare. Direct luminaires that are immediately over an individual can cause glare even though the light source is not in the field of view. This type of glare can produce the same negative effects as direct or reflected glare including eye-strain and headaches.

3.3.1 To minimize overhead glare, use indirect luminaires to light the ceiling surface and avoid totally direct luminaires. Where direct luminaires are used, make sure that individuals are not working directly under them.

3.4 Requirements to minimize glare:

- Follow IESNA recommendations for individual lighting application. Refer to the *Lighting Handbook*, Chapter 10 “Quality of the Visual Environment” for specific criteria.

3.5 Considerations to minimize glare:

- Indirectly light the ceiling and walls for interior ambient lighting systems.
- Use direct light only in limited amounts for task and accent light.
- For exterior applications, use fully shielded luminaires.

4 UNIFORMITY. Lighting level or illuminance uniformity is important on work surfaces where sustained tasks are performed as well as on wall and ceiling surfaces that make up a significant portion of the field of view. Poor uniformity can cause adaptation problems. It is very important to prevent “spotty” lighting especially in interior areas where people are working, and exterior areas where safety and security are concerns.

4.1 Flicker or strobing of luminaires can cause annoyance as well as headaches and fatigue. This may be caused by fluorescent ballasts near the end of life or placement of luminaires in relation to ceiling fans. If ceiling fans are required in a space, position the luminaires so that they are suspended below the level of the fans.

4.2 Requirements for appropriate uniformity:

- Follow IESNA uniformity criteria for specific areas unless superseded by other UFC criteria. Refer to specific application requirements in Chapter 10 of the *Lighting Handbook*.

4.3 Considerations for appropriate uniformity:

- In office areas, uniformity should not exceed 5:1 in immediate work surrounds, not including accent lighting.
- Exterior uniformity should not exceed 10:1 along areas of use including roadways, walkways, and parking areas.

5. ILLUMINANCE. Illuminance refers to the light level, or amount of light falling on a surface. It is measured in lux or footcandles. Horizontal illuminance refers to the amount of light falling on a horizontal surface. This type of illuminance is often measured on a desk, work surface, or floor. Vertical illuminance refers to the amount of light falling on a vertical surface such as white boards, signs, and walls. Vertical illuminance on peoples’ faces is also important for identification at entries and security checkpoints.

5.1 Traditionally, illuminance has been the basis of lighting design. However, we "see" brightness; we don't see lighting levels or lux. Since the revision of the IESNA guidelines, new standards regarding design must be followed. The *Lighting Handbook* chapter on "Quality of the Visual Environment" (QVE) has added many other design factors besides illuminance. It is important to review all of the design criteria issues in order to prioritize issues. In many cases illuminance is no longer a top priority. Lighting wall and ceiling surfaces is usually more important than providing high levels of horizontal illuminance. In order to provide flexibility and interest in a space, light ceiling and wall surfaces with lower ambient lighting levels. Provide higher illuminance levels with individualized task lighting.

5.2 There are three different types of visual responses: Photopic or our day vision (3 cd/m² and higher), Scotopic or our night vision (.001 cd/m² and below) and mesopic or a combination of night and day vision (.001 cd/m² to 3 cd/m²). (*Lighting Handbook* page 1-6). The majority of exterior lighting is designed in the mesopic range.

5.2.1 Photopic sensitivity peaks at 555 nm in the green-yellow range. Scoptoic vision sensitivity peaks at 507 nm more in the blue light range. Mesopic vision varies between these values depending on the lighting level. As the lighting levels become lower, lamp sources with more blue light become more effective in nighttime vision.

5.2.2 Since lamp lumen ratings are all based on photopic sensitivity, they need to be adjusted for nighttime applications. Photopic and scotopic lumens must be determined from the spectral power distribution of the light source (*Lighting Handbook* page 1-6.) In addition, photopic luminous efficiency function applies to visual fields of size 2 degrees or less. (*Lighting Handbook* page 2-1). This means that only tasks that are on-axis or one that is focusing straight ahead apply to the photopic lamp lumen ratings. Any task that is in our peripheral vision does not. Peripheral vision shifts to shorter wavelength sensitivity. (*Lighting Handbook* page 3-9).

5.2.3 There are numerous research projects evaluating the most effective method of determining mesopic lumen ratings for lamp sources. All of these methods show a significant effectiveness of a white light source such as metal halide over a high

pressure sodium light source. An example used by Dr. Mark Rae (editor of the *Lighting Handbook*) shows that for a typical roadway luminance of 0.3 cd/m^2, a 400 watt HPS produces 135 lux (13.5 footcandles) and consumes 400 watts plus ballast watts. A metal halide system with equal visibility produces 86 lux (8.6 footcandles) consuming 335 watts plus ballast watts.

5.2.4 For all exterior lighting applications where peripheral vision is important such as detecting pedestrians and other potential off axis activity, white light as produced by a metal halide, fluorescent, or induction lamp is recommended.

5.2.5 Lumen effectiveness multipliers may be used to account for the improved visibility provided by white light as opposed to HPS. Determine the appropriate luminance condition and the source being used. Note that most computer lighting programs can calculate luminance as an option. This value is then multiplied by the lumen output of the lamp published by the manufacturer to determine the *effective* lumens. Notice that during photopic (10 cd/m^2) conditions, the multiplier for all sources is 1.00 and no adjustment needs to be made to the lamp lumen output. At lower brightness levels, white metal halide light becomes more effective and low-pressure sodium becomes less effective. (Because sources are being compared, one must be set as baseline. In this case, high-pressure sodium is the base and all values are 1.0 under any brightness condition.)

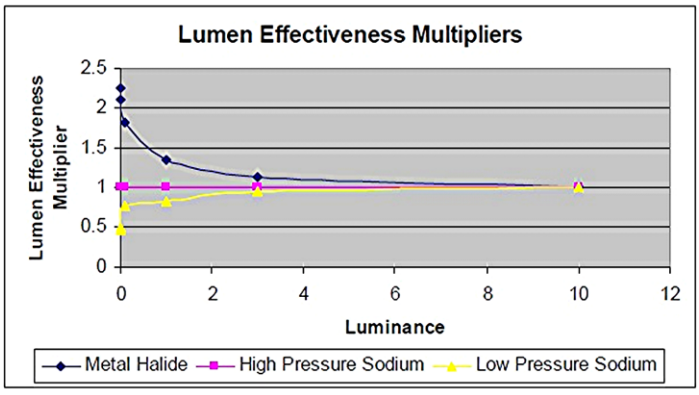


Figure 1





Figure 2
Examples of direct glare





Figure 2 (continued)
Examples of direct glare



Figure 3
Minimize direct glare with IESNA full cut-off luminaire.

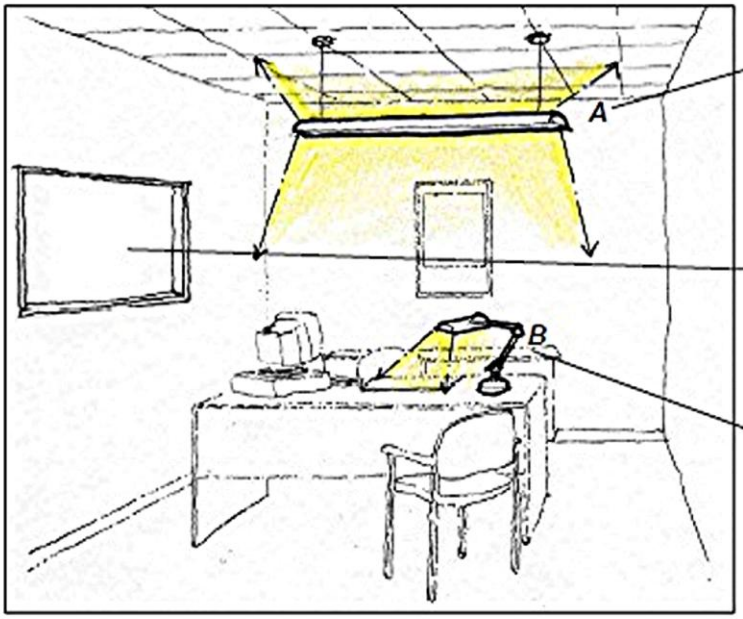


Figure 4
Minimize direct glare with indirect lighting.

6. INTERIOR LIGHTING EXAMPLES.

Following are a few examples of interior lighting situations.

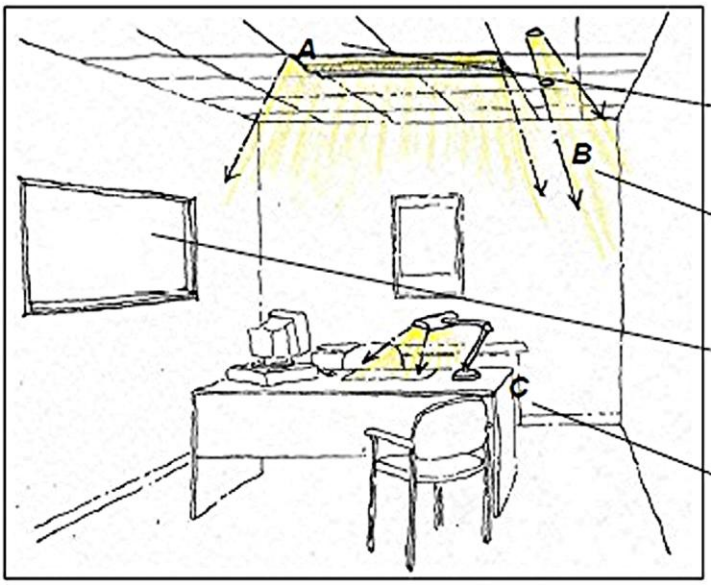
OFFICES **Individual Offices**



EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Pendant mounted linear fluorescent, indirect / direct luminaire, mounted 0.5 – 0.9m (18" – 36") below ceiling*	*4' linear fluorescent T8 lamps 3500K color temperature, 75 CRI +*	*Daylight dimming or switching or connected to occupancy sensor. Control ambient and accent lighting separately.*
B	*Task light*	*Compact or linear fluorescent lamp, 3500K color temperature, 80 CRI +*	*Manual on/off or connected to occupancy sensor.*

OFFICES — Individual Offices (Alternate Scheme)



EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Recessed linear fluorescent direct/indirect luminaire.*	*4' linear fluorescent T8 lamps 3500K color temperature, 75 CRI +*	*Daylight dimming or switching or connected to occupancy sensor. Control ambient and accent lighting separately.*
B	*Recessed compact fluorescent downlight wallwasher.*	*Compact fluorescent lamp 3500K color temperature, 80 CRI +*	*Daylight dimming or switching. Control ambient and accent lighting separately.*
C	*Task light*	*Compact or linear fluorescent lamp, 3500K color temperature, 80 CRI +.*	*Manual on/off or connected to occupancy sensor.*

CRITICAL DESIGN ISSUES:

- Direct Glare: Lamps in the luminaire are shielded with louvers, perforations, or lenses to avoid a view of the lamps and the resultant direct glare.
- Luminances of Room Surfaces: Room surfaces need to be illuminated to control the contrast between the occupant's task and the surrounding surfaces in that person's field of view. This is especially important with computer use when a person views a bright screen in the foreground. If the background is too dark, the contrast will lead to eyestrain and fatigue.
- Uniformity: Luminance uniformity should not exceed 5:1 in immediate work surrounds, not including accent lighting.
- Reflected Glare: When viewing tasks with a glossy finish, bright luminaire components such as visible lamps or bright lenses reflect in the surface of the task. This situation can make reading tasks annoying and at times impossible.
- Source / Task eye geometry: Task areas and luminaire locations need to be identified to avoid shadows and direct and reflected glare.

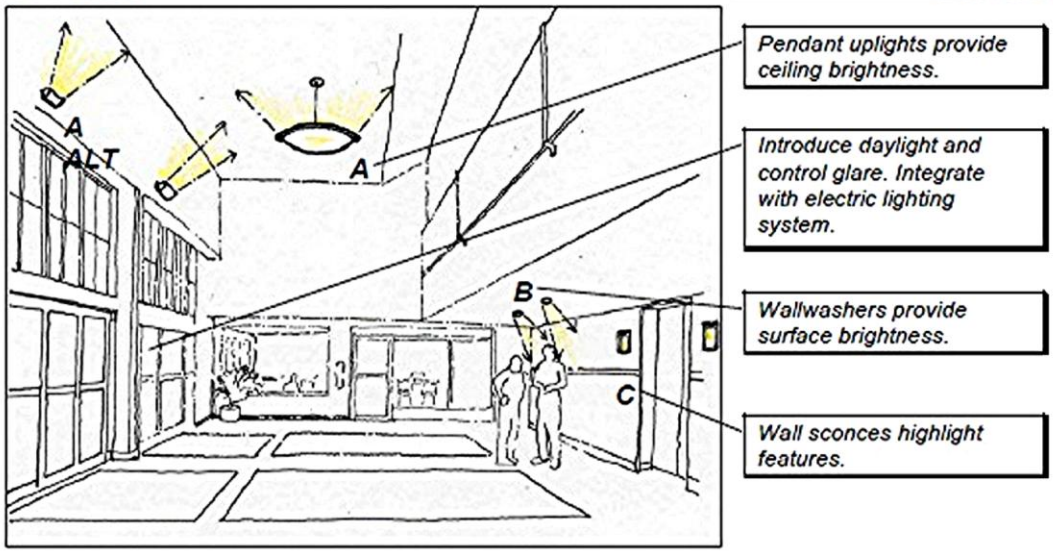
• Target Horizontal Illuminance (± 10%): 300 lux (30 fc) ambient, 500 lux (50 fc) on the task

DISCUSSION:

A task/ambient approach to the lighting in an individual office results in separate control over an ambient system (typically a pendant mounted direct/indirect luminaire) and task lighting (a desk or under cabinet light). In larger offices or interior offices, additional wall washing may be necessary to add wall surface brightness. By providing a high illuminance level on the task only and not the entire room, energy is saved in the ambient system, which does not have to produce as much light. This approach also provides a comfortable and flexible lighting environment.

Control devices could be as simple as manual on/off or dimming of the separate systems. Occupancy sensors (individual or incorporated into wall switches) save additional energy when someone is not in the office.

OFFICES — Lobbies



EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Pendant mounted decorative luminaire.*	*Compact fluorescent lamps, 3500K color temperature, 80 CRI + or metal halide*	*Daylight dimming or switching.*
A ALT	*Wall mounted uplight.*	*Compact fluorescent lamps, 3500K color temperature, 80 CRI + or metal halide*	*Daylight dimming or switching.*
B	*Recessed compact fluorescent wallwasher*	*Compact fluorescent lamp, 3500K color temperature, 80 CRI +*	*Daylight dimming or switching.*
C	*Wall mounted compact fluorescent sconce.*	*Compact fluorescent lamp, 3500K color temperature, 80 CRI +*	*Timeclock On / Off, coordinated with building schedule.*

CRITICAL DESIGN ISSUES:

- Daylighting Integration and Control: Many lobbies are designed with daylight as a primary feature of the space. By integrating lighting controls with the daylight design, electric lighting equipment can be turned off when not required.
- Appearance of Space and Luminaires: Because lobbies are often the first space visitors to the building see, the aesthetic appearance of the space and the luminaires is an important criterion. Luminaire layout should avoid “visual clutter” of the space.
- Luminance of Room Surfaces: Downlighting the volume of a space from a high ceiling consumes a lot of energy. Lighting the wall and ceiling surfaces can achieve increased brightness with less energy. Typically people spend a limited amount of time in such spaces and are not occupied with difficult visual tasks. Therefore, the luminances of the surfaces are far more important than the horizontal illuminance.
- Color Appearance (and Color Contrast): The color of accent walls, architectural features, and artwork needs to be rendered accurately. For this reason, tungsten halogen, fluorescent or ceramic metal halide lamps with a high color-rendering index (CRI) should be used to accent such features.

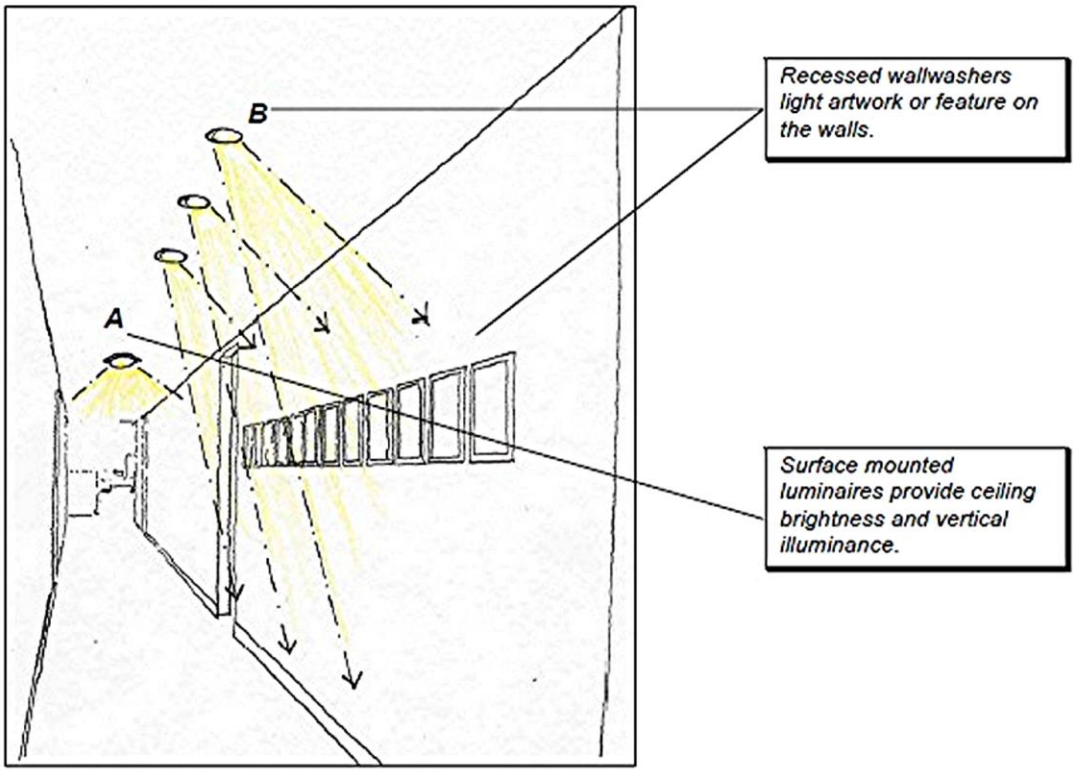
- Modeling of Faces or Objects: Ambient lighting for lobby spaces should include indirect lighting and come from multiple directions and angles. For example, if multiple systems such as sconces, pendants, and wallwashers all provide light from multiple directions, three-dimensional objects will appear three dimensional in form. However, if all of the lighting is aimed straight down at the floor, objects in the space will have harsh shadows and appear “flat”.
- Target Horizontal Illuminance (± 10%): 100 lux (10 fc)

DISCUSSION:

As in most interior spaces, lobbies require the lighting of surfaces as opposed to volumes. In such high spaces, high wattage downlights are often recessed into the ceiling and aimed at the floor. After traveling through the entire volume of the space, very little light reaches the floor only to illuminate a low reflectance surface. Downlights can also create harsh shadows on people and objects.

A more effective and energy efficient lighting scheme illuminates high reflective surfaces as well as specific features in an ambient / accent approach. In the figure above, decorative pendants light the ceiling. This ambient system also can be easily integrated with the available daylight in the space. Wall washers illuminate walls and artwork and sconces identify the elevator doors, assisting in wayfinding for building visitors.

OFFICES — Corridors



EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Surface mounted compact fluorescent luminaires.*	*Compact fluorescent lamp 3500K color temperature, 80+ CRI*	*Daylight switching if available. Consider occupancy sensors for low use corridors or after hours.*
B	*Recessed compact fluorescent downlight / wallwashers*	*Compact fluorescent lamp 3500K color temperature, 80+ CRI*	*Daylight switching if available. Consider occupancy sensors for low use corridors or after hours.*

CRITICAL DESIGN ISSUES:

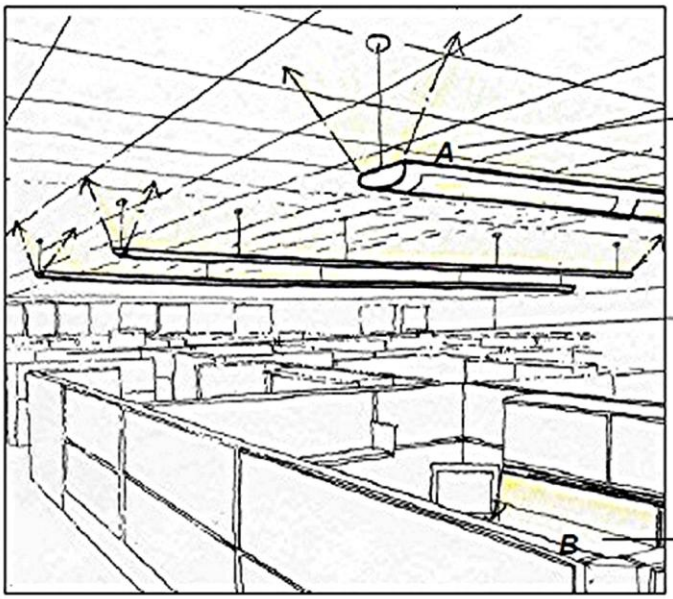
- Daylight Integration and Control: If daylight can be introduced into corridors, the corridor's electric lighting can be turned off when there is adequate light. In infrequently used corridors, occupancy sensors can also be used to provide light only when needed.
- Direct Glare: Avoid direct glare even in transitional spaces such as corridors.
- Light Distribution on Surfaces: Lighting surfaces increases the perceived brightness of the space, makes the space feel larger, and can reduce the amount of energy required.
- Modeling of Faces or Objects: Light should come from multiple directions to adequately light individuals in the corridor. A system of downlights will cast harsh shadows on an occupant's face.
- Point(s) of Interest: Lighting photos, art, or other displayed features in a corridor can break the repetition of the lighting and add interest to the corridor. It also illuminates a surface that is prominent in the occupant's field of view.

• Target Horizontal Illuminance (± 10%): 50 lux (5 fc)

DISCUSSION:

Although people spend little time in such transitional spaces, corridors can feel small and cramped with poor lighting and can represent a significant energy use. Lighting ceiling and wall surfaces increases the surface brightness and the overall perceived brightness of the space. This also makes the space feel larger and wider and can do so with the same or less energy than a downlighting only scheme. Surface mounted luminaires add vertical brightness on faces and also can help in indicating corridor intersections.

OFFICES — Open Offices



Pendant mounted direct/indirect luminaires selected and located to prevent direct and reflected glare.

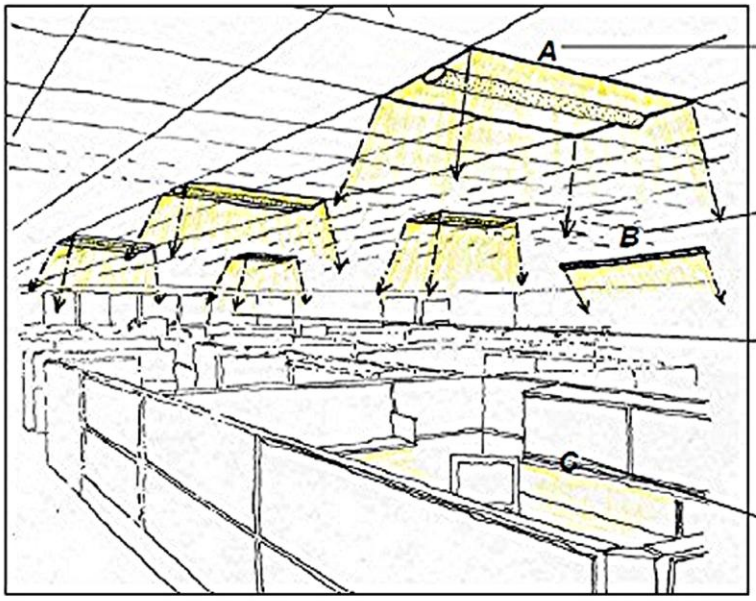
Introduce daylight from north and south facades and control glare. Integrate daylight with electric lighting system where appropriate.

Undercabinet task lights increase illuminance on desks.

EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Pendant mounted linear fluorescent, indirect / direct luminaire, mounted 0.5 – 0.9m (18" – 36") below ceiling. (There are some luminaires available for ceiling heights of 8' with short pendants.)*	*4' linear fluorescent T8, T5HO lamps 3500K color temperature, 75 CRI +*	*Daylight dimming or switching. Manual dimming over workstations is also available. Consider the use of occupancy sensors for cubicle groups.*
B	*Under cabinet task lighting designed for minimal veiling reflections.*	*2', 3', and 4' linear fluorescent T8 lamps 3500K color temperature, 75 CRI +*	*Manual on/off or on local occupancy sensor.*

OFFICES — Open Offices (Alternate Scheme)



Recessed direct/indirect luminaires.

Recessed wallwashers increase surface brightness of walls.

Introduce daylight from north and south facades and control glare. Integrate daylight with electric lighting system where appropriate.

Undercabinet task lights increase illuminance on desks.

EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Recessed linear fluorescent direct/indirect luminaire.*	*4' linear fluorescent T8, T5HO lamps 3500K color temperature, 75 CRI +*	*Daylight dimming or switching. Manual dimming over work stations is also available. Consider the use of occupancy sensors for cubicle groups.*
B	*Recessed compact or linear fluorescent wallwashers.*	*4' linear fluorescent T8, T5HO or compact fluorescent lamps 3500K color temperature, 75 CRI +*	*Daylight dimming or switching. Consider the use of occupancy sensors for cubicle groups.*
C	*Under cabinet task lighting.*	*2', 3', and 4' linear fluorescent T8, T5, or T2 lamps 3500K color temperature, 75 CRI +*	*Manual on/off or on local occupancy sensor.*

CRITICAL DESIGN ISSUES:

- Direct Glare: Lamps in the luminaires are shielded with louvers, perforations, or lenses to avoid a view of the lamps and direct glare.
- Luminances of Room Surfaces: Room surfaces need to be illuminated to control the contrast between the occupant's task and the surrounding surfaces in that person's field of view. This is especially important with computer use when a person views a bright screen in the foreground. If the background is too dark the contrast will lead to eyestrain and fatigue. In a

large open office, the ceiling may be more prominent in someone's field of view than the walls.

- Uniformity: Luminance uniformity should not exceed 5:1 in immediate work surrounds, not including accent lighting.
- Reflected Glare: With high computer use, the ceiling brightness must be uniform to prevent reflected glare in computer screens. When viewing tasks with a glossy finish on a desktop, bright luminaire components such as visible lamps or lenses reflect in the surface of the task. This situation can make reading tasks annoying and at times impossible.

- Source / Task eye geometry: Task areas and luminaire locations need to be identified to avoid shadows and direct and reflected glare.
- Target Horizontal Illuminance (± 10%): 30 lux (30 fc) ambient, 500 lux (50 fc) on the task.

DISCUSSION:

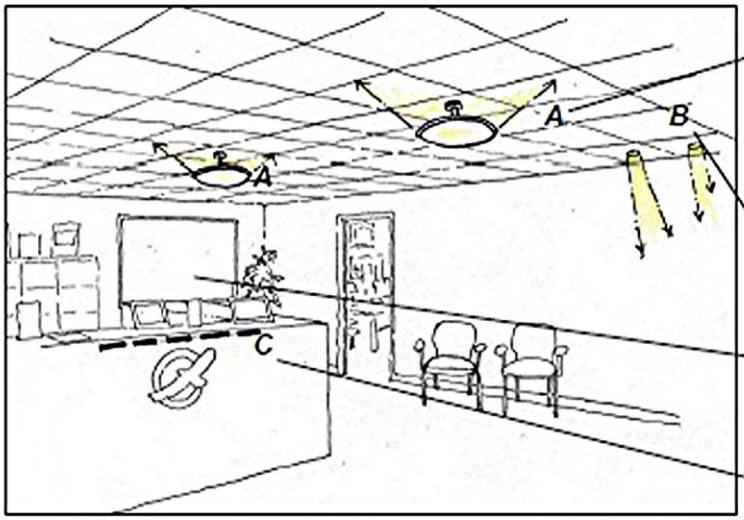
A task/ambient approach to the lighting in open offices results in separate control over an ambient system (typically a pendant mounted direct/indirect luminaire) and task lighting (a desk light or under cabinet luminaire). Design the under cabinet task light to minimize veiling reflections by directing light away from or to either side of the task. By providing a high illuminance level on the task only, and not the entire room, energy is saved in the ambient system, which does not have to produce as much light. This approach also provides a comfortable and flexible lighting environment. Manual dimming can also be incorporated with the use of remote controls at individual workstations that control only the nearby luminaires.

Integrating daylight with the electric lighting system greatly enhances the visual comfort of the space and can save significant amounts of energy. Depending on the configuration of workspaces and windows, lighting near the perimeter of the space may be controlled as a separate lighting zone from the lighting towards the interior of the space. In such a case, perimeter luminaires may be turned off entirely during the day while only using some portion of the lighting in the interior of the office.

RULES OF THUMB:

- Pendant spacing: When beginning a design, start with 3.0 – 3.7m (10 – 12 ft) spacing for T8 luminaires (5.5 – 6.0 m or 18 – 20 ft for T5HO systems) and modify accordingly to meet critical design issues.
- Pendant length: Pendant lengths range from 0.5 – 0.9 m (18 in – 3 ft). High performance luminaires may achieve a minimum of 0.3 m (12 in) pendant lengths. Specialty luminaires for low ceiling applications may be mounted even closer to the ceiling.
- Lighting Power Density: The lighting power density for open office areas can range from 0.9 – 1.2 watts /sq ft.

OFFICES — Waiting Areas



Pendant or surface mounted luminaires provide surface brightness and vertical illuminance.

Recessed wallwashers or accent lights increase wall brightness and highlight features.

Introduce and control daylight. Integrate with electric lighting system to reduce energy use.

Task lighting increases the illuminance on a task, allowing the ambient light levels to be lower.

EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Pendant or surface mounted decorative luminaire.*	*Compact fluorescent lamps, 3500K color temperature, 80 CRI +*	*Consider daylight dimming or switching.*
A ALT	*Recessed direct / indirect linear fluorescent luminaire.*	*Linear fluorescent lamps, 3500K color temperature, 75+ CRI*	*Consider daylight dimming or switching.*
B	*Recessed compact fluorescent downlight/wallwasher.*	*Compact fluorescent lamps, 3500K color temperature, 80 CRI +*	*Consider daylight dimming or switching.*
C	*Linear fluorescent desk task lighting over desks.*	*2', 3', and 4' linear fluorescent T8, T5, or T2 lamps 3500K color temperature, 75 CRI +*	*Manual on / off or local occupancy sensor.*

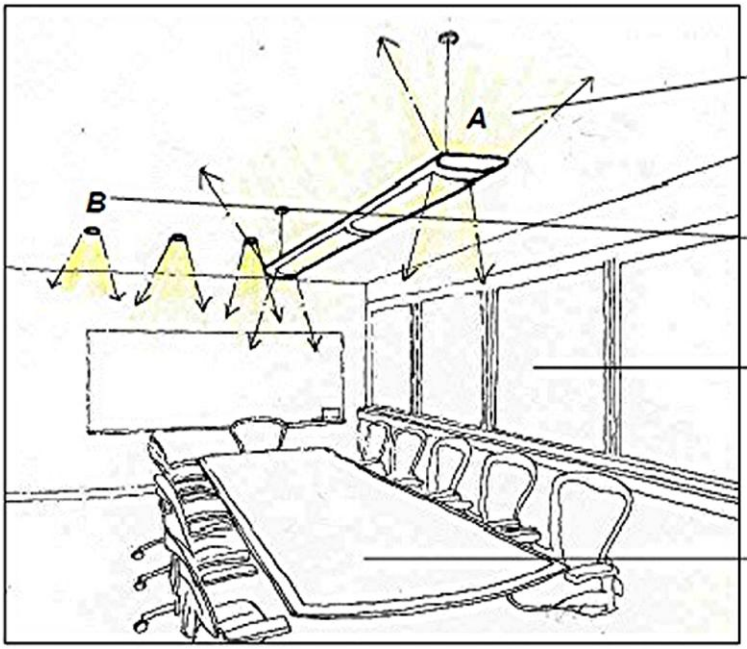
CRITICAL DESIGN ISSUES:

- Daylighting Integration and Control: If daylight can be introduced into waiting areas, the electric lighting can be turned off when there is adequate light.
- Appearance of Space and Luminaires: Because facility visitors often occupy waiting areas, the aesthetic appearance of the space and the luminaires is an important criterion.
- Target Horizontal Illuminance (± 10%): 100 lux (10 fc) ambient, 500 lux (50 fc) on the task

DISCUSSION:

An effective and energy efficient lighting scheme illuminates high reflective surfaces as well as specific features in an ambient / accent approach. In the figure above, decorative pendants or surface mounted luminaires light the ceiling. This ambient system also can be easily integrated with the available daylight in the space. Wall washers illuminate walls and artwork. Because the walls make up a significant portion of our field of view, brightness on these surfaces increases the overall perceived brightness of the space.

OFFICES — Conference Rooms



EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Pendant mounted linear fluorescent, indirect / direct luminaire, mounted 0.5 – 0.9m (18" – 36") below ceiling*	*4' linear fluorescent T8 lamps 3500K color temperature, 75 CRI +*	*Manual dimming or switching with occupancy sensors.*
B	*Recessed compact fluorescent downlight / wallwashers.*	*Compact fluorescent lamp. 3500K, 80+ CRI.*	*Manual on / off or manual on/ occupancy sensor off.*

CRITICAL DESIGN ISSUES:

- Appearance of Space and Luminaires: Because building visitors often meet in conference rooms, the aesthetic character of the luminaires is an important consideration.
- Direct Glare: Lamps in the luminaires are shielded with louvers, perforations, or lenses to avoid a direct view of the lamps and the resultant glare.
- Light Distribution on Surfaces: Illuminate the room surfaces uniformly, especially the ceiling and walls. Patterns of light or shadows on surfaces can be distracting and confusing.
- Light Distribution on Task Plane: The lighting system should provide a uniform distribution of light on the conference table with minimal shadowing. This will provide a comfortable environment for writing tasks without causing fatigue or eyestrain.
- Luminance of Room Surfaces: Luminance, or brightness, of the room surfaces determines the perception of the conference room. With a bright, uniform ceiling and evenly washed walls, the space will feel bright and visually comfortable.
- Modeling of Faces or Objects: Because presentations and meetings are typical tasks in conference rooms, the lighting system should model people comfortably and accurately. Lighting that softly illuminates individual's faces without harsh shadows or excessive contrast reveals facial expressions and enhances such non-verbal communication.
- System Control and Flexibility: Control of luminaires should allow for multiple scenes or uses of the space. For example, a slide presentation may require lower ambient light levels, but adequate light on

the table for occupants to take notes or read a handout. Window shades can darken the room for presentations. Other uses such as meetings may require more light.

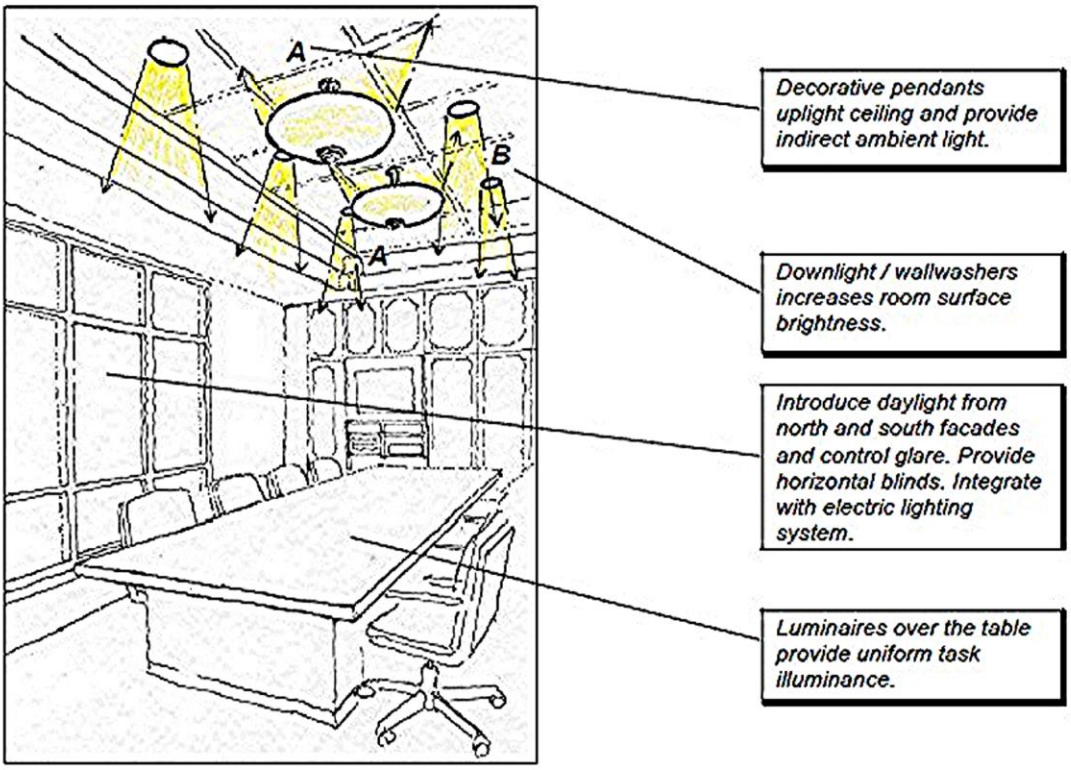
- Target Horizontal Illuminance (± 10%): 300-500 lux (30-50 fc)

DISCUSSION:

The general ambient lighting must include an indirect component. A system comprised of downlighting only poorly illuminates room surfaces and puts harsh shadows on occupant's faces. Using an indirect component as part of the overall system will create a brighter space with better room surface luminances and render people more comfortably.

The lighting in a conference room should adapt to multiple uses of the space. At times, a presentation may require light on a white board or presentation wall. Other presentations may require a darker space for slide shows but still provide some light on the table so occupants can still take notes. For meetings, general lighting from a pendant over the table may be all that is required. Zone the luminaires separately to allow for the creation of multiple scenes depending on the space's use.

OFFICES — Boardrooms / Large Conference Rooms



EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Pendant mounted decorative fluorescent, indirect / direct luminaire.*	*Compact fluorescent lamp. 3500K, 80+ CRI.*	*Manual dimming or switching. Consider the addition of occupancy sensors.*
B	*Recessed compact fluorescent downlight / wallwashers.*	*Compact fluorescent lamp. 3500K, 80+ CRI.*	*Manual on / off. Consider the addition of occupancy sensors.*

CRITICAL DESIGN ISSUES:

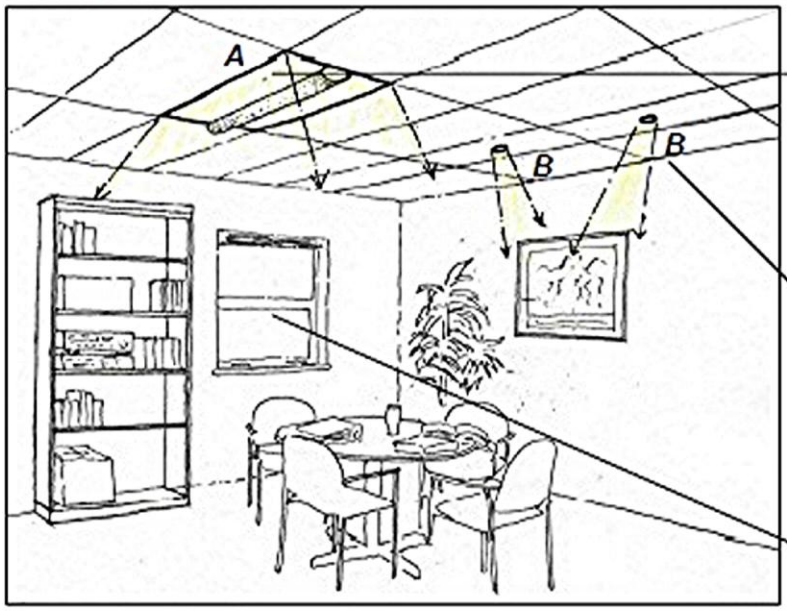
- Appearance of Space and Luminaires: Because building visitors often meet in boardrooms and large conference rooms, the aesthetic character of the luminaires is an important consideration.
- Direct Glare: Lamps in the luminaires are shielded with louvers, perforations, or lenses to avoid a direct view of the lamps and the resultant glare.
- Luminance of Room Surfaces: Luminance, or brightness, of the room surfaces determines the perception of the room. With a bright, uniformly lighted ceiling and evenly washed walls, the space will feel bright and visually comfortable. Increase brightness on architectural features or artwork to highlight certain areas.
- Modeling of Faces or Objects: Like conference rooms, presentations and meetings are typical tasks in boardrooms and the lighting system should model speakers as well as meeting participants. Lighting that softly illuminates individual's faces without harsh shadows or excessive contrast reveals facial expressions and enhances such non-verbal communication.

- Reflected Glare: When viewing tasks with a glossy finish on a tabletop, bright luminaire components, such as visible lamps or bright lenses reflect in the surface of the task. This situation can make reading tasks annoying and at times impossible.
- Target Horizontal Illuminance (± 10%): 300-500 lux (30-50 fc)

DISCUSSION:

Similar to conference rooms, the lighting of boardrooms and large conference rooms should adapt to multiple uses of the space. At times, a presentation may require light on a white board or presentation wall. Other presentations may require a darker space for slide shows but still provide some light on the table so occupants can still take notes. For meetings, general lighting from a pendant over the table may be all that is required. Zone the luminaires separately to allow for the creation of multiple scenes depending on the space's use. Manual dimming allows a wide range of light levels for these varied requirements. Manual blinds for windows provide additional control over the daylight and ambient light levels.

OFFICES — Lounge Areas



EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Recessed direct / indirect linear fluorescent luminaire.*	*Linear fluorescent T8 or T5HO lamps, 3500K color temperature, 75 CRI +*	*Daylight dimming or switching and occupancy sensor.*
B	*Recessed compact fluorescent downlight / wallwasher.*	*Compact fluorescent lamps, 3500K color temperature, 80+ CRI*	*Daylight dimming or switching and occupancy sensor.*

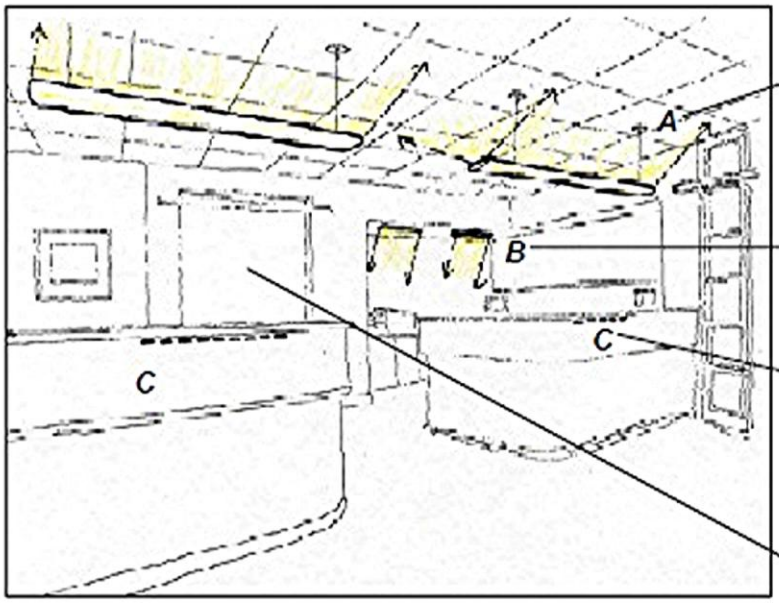
CRITICAL DESIGN ISSUES:

- Daylighting Integration and Control: The introduction of daylight into lounge areas can help to make it a more relaxing and inviting space. Use daylight controls to turn off unnecessary electric lighting.
- Luminance of Room Surfaces: The room will feel bright if surfaces are illuminated. A recessed direct / indirect luminaire puts some light on the ceiling if the shielded “basket” drops below the ceiling plane. The use of downlight wallwashers highlights artwork or just adds to the overall brightness of the space.
- Color Appearance (and Color Contrast): The color of accent walls, architectural features, and artwork needs to be rendered accurately.
- Modeling of Faces or Objects: With casual conversation taking place in lounges, individual’s faces should be illuminated well without harsh shadows.
- Target Horizontal Illuminance (± 10%): 100 lux (10 fc)

DISCUSSION:

The introduction of daylight is a priority in lounge areas. Additionally, an ambient / accent approach to the lighting system will provide visual interest in the space and also some variety and flexibility in the control. While breaking the system into ambient and accent components, take care to avoid visual clutter with too many types of luminaires or poor layout. The luminaire selection should reinforce a casual and comfortable atmosphere.

OFFICES — Office Support Areas



Direct/indirect luminaires selected and located to prevent direct and reflected glare.

Recessed wallwashers increase wall brightness.

Task lighting increases the illuminance on a task, allowing the ambient light levels to be lower.

Introduce and control daylight on north and south facades. Integrate with electric light controls to reduce energy use.

EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Pendant mounted linear fluorescent, indirect / direct luminaire, mounted 0.5 – 0.9m (18" – 36") below ceiling*	*4' linear fluorescent T8 lamps 3500K color temperature, 75 CRI +*	*Daylight or manual dimming or switching. Consider the use of occupancy sensors for cubicle groups.*
B	*Recessed linear fluorescent wall washer.*	*2', 3', and 4' linear fluorescent T8 lamps 3500K color temperature, 75 CRI +*	*Manual on / off or local occupancy sensor.*
C	*Linear fluorescent desk task lighting over desks.*	*2', 3', and 4' linear fluorescent T8, T5, or T2 lamps 3500K color temperature, 75 CRI +*	*Manual on / off or local occupancy sensor.*

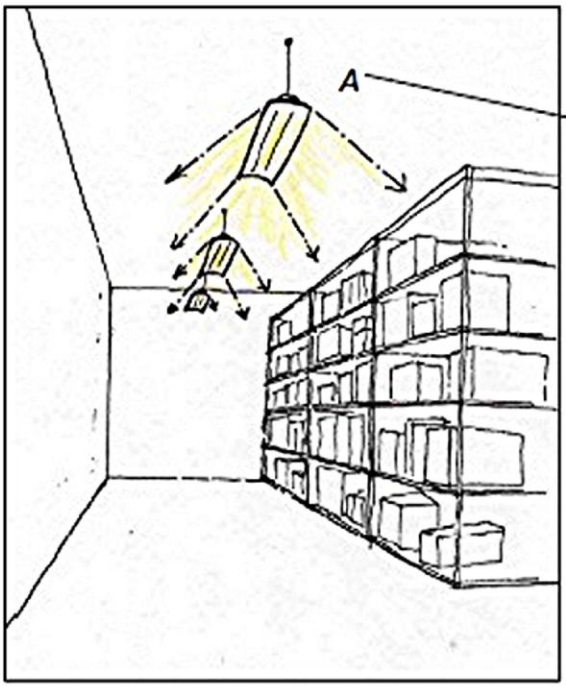
CRITICAL DESIGN ISSUES:

- Direct Glare: Visible lamps and bright lenses can cause glare, leading to eyestrain and eye fatigue.
- Reflected Glare: Bright lamps and lenses can be reflected in polished room surfaces, computer screens, and glossy printed tasks. These reflections reduce the contrast of tasks making reading extremely difficult. Shielding or diffusing lamps and specifying matte finishes where appropriate can improve the visual quality of the space and avoid reflected glare. Locate under-cabinet task lights to direct light away from or to either side of the task.
- Source / Task eye geometry: Identify task areas and design lighting to minimize shadows and glare (both direct and reflected).
- Target Horizontal Illuminance (± 10%): 300 lux (30 fc) ambient, 500 lux (50 fc) on task.

DISCUSSION:

Office support areas require the same range of lighting levels as other office task spaces. By breaking the lighting system into ambient and task components, the ambient levels can be low while increasing the illuminance on the task only. This approach reduces energy consumption.

OFFICES — Storage Rooms



EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Pendant or surface mounted linear fluorescent luminaire.*	*4' linear fluorescent T8 lamps (or T5HO lamps for ceilings over 15') 3500K color temperature, 75 CRI +*	*Occupancy sensor or timer switch.*

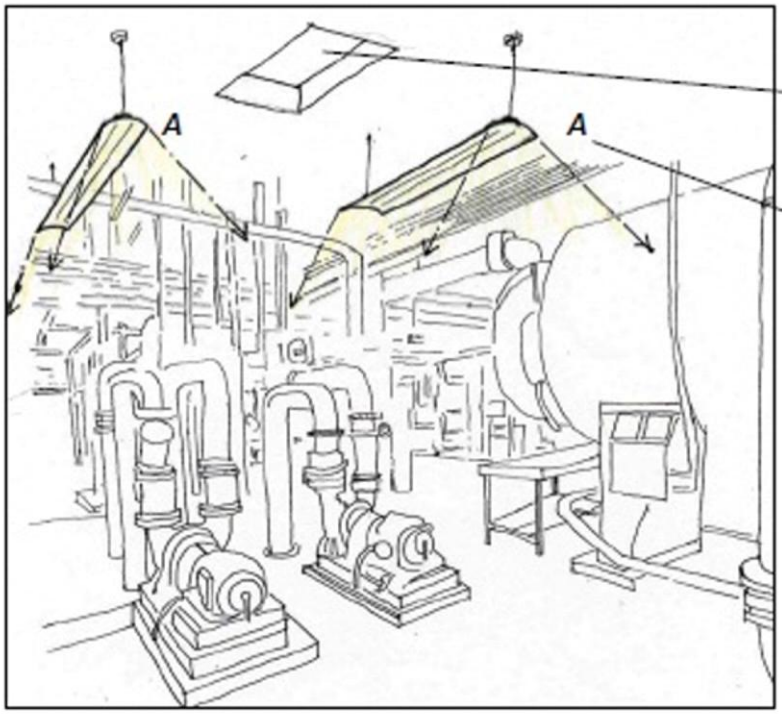
CRITICAL DESIGN ISSUES:

- Color Appearance (and Color Contrast): In storage rooms, individuals may need to locate and sort items. Lamp sources should have a high color-rendering index to accurately portray colors and labels.
- Source / Task eye Geometry: Locate luminaires to minimize direct glare and light shelves uniformly with minimal shadowing.
- Target Vertical Illuminance (± 10%): 100 lux (10 fc)

DISCUSSION:

In storage rooms, uniform vertical illuminance on shelves helps with the identification of items. In small storage closets, a linear fluorescent strip mounted horizontally above the door provides indirect light and minimizes shadows on the shelves.

OFFICES — Mechanical Rooms



EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Pendant mounted linear fluorescent industrial strip with 5%-10% uplight component.*	*4' linear fluorescent T8 lamps (or T5HO lamps for ceilings over 15') 3500K color temperature, 75 CRI +*	*Occupancy sensor or timer switch.*

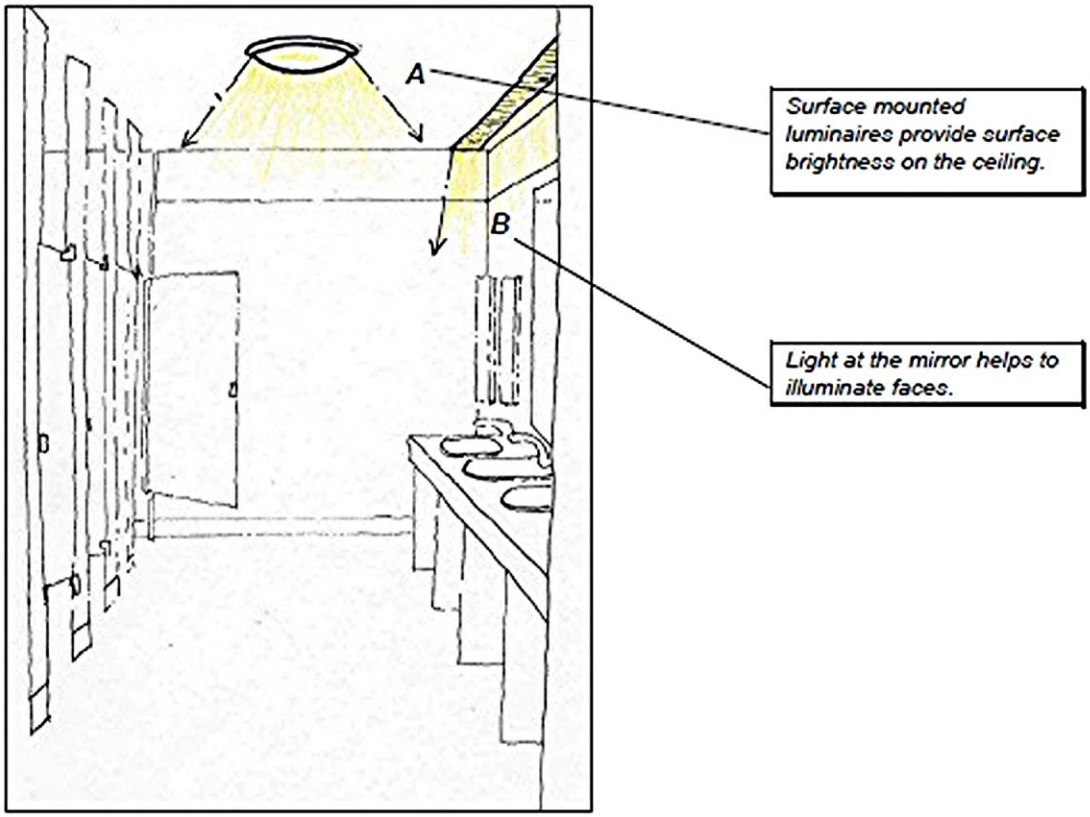
CRITICAL DESIGN ISSUES:

- Shadows: Locate and orient luminaires to avoid shadowing of mechanical equipment. Typically, equipment repair requires portable task lighting. Therefore, lighting should provide clear access to systems but not necessarily enough light to make repairs.
- Target Horizontal Illuminance (± 10%): 300 lux (30 fc)

DISCUSSION:

Adequate light needs to be provided for ease of navigation through mechanical rooms. Although mechanical rooms may not be used frequently or for long periods of time, if the lights are left on, a significant amount of energy can be wasted before the next use of the space. For larger spaces, consider the use of occupancy sensors. In small spaces, a control with a timer may be suitable.

OFFICES — Restrooms



EQUIPMENT RECOMMENDATIONS:

	LUMINAIRE	LAMP	CONTROLS
A	*Surface or wall mounted compact fluorescent luminaire.*	*Compact fluorescent lamps, 3500K color temperature, 80 CRI +*	*Occupancy sensor.*
B	*Recessed linear fluorescent wall slot.*	*4' linear fluorescent T8 lamps 3500K color temperature, 75 CRI +*	*Occupancy sensor.*

CRITICAL DESIGN ISSUES:

- Color Appearance (and Color Contrast): The color-rendering index of fluorescent lamps should be high to render colors well and avoid a pale or blue look to individual's faces.
- Modeling of Faces or Objects: With light coming from multiple directions and angles, faces and objects can be modeled well without harsh shadows.
- Target Horizontal Illuminance (± 10%): 50 lux (5 fc), higher light level at mirrors

DISCUSSION:

While the recommended ambient light level for restrooms is low, lighting the walls and putting some brightness on the ceiling will increase the perceived brightness of the space. Increased light levels are appropriate at the sink or counter near the mirrors.

Occupancy sensors should control the lighting in restrooms where luminaires are frequently left on for an extended period of time. Ceiling mounted, ultrasonic sensors recognize occupants even in a space with high partitions. Locate and aim the sensor to switch on when the door opens and then turn off after a pre-determined amount of time.