

From Books to Computers

Lighting the Office and Education environment.

Reference:

IESNA Handbook Chapter 11: Office Lighting
Recommended Practice RP-1

IESNA Handbook Chapter 12: Educational
Facility
Recommended Practice RP-3

Why from books to computers?

Lighting the Office and Education environment have common task.

- Reading and Writing
- Social Communication
 - Seeing and Talking to people up close
 - Seeing and Talking to people from afar
- Room used for learning
 - Classrooms
 - Lecture Rooms
- Library
 - Book Stacks
 - Storage
- Corridors and Circulation

The Purpose of Lighting

Educational Facilities

The overarching goal of educational facility lighting is to provide a visual environment for both students and instructors that is supportive of the learning processes.

This can be achieved only if the occupants can see their visual tasks accurately, quickly, and comfortably.

Uniform horizontal illuminance throughout an educational facility does not necessarily ensure high levels of visual performance because of the great variety of visual tasks, including visual display terminal (VDT) tasks, found in a school.

Lighting can make a school pleasant and attractive, reinforce feelings of spaciousness, delineate areas of different functions, stimulate learning, and improve behavior.

Office Environment

Offices are designed to house working people engaged in thought and in a number of forms of communication (written, visual, telephone, computer, and face to face). Office lighting should enable workers to perform these tasks effectively.

Since feelings of well-being, interest, and enthusiasm are affected by the environment, consideration should be given to the design of office interiors in an effort to achieve a stimulating work place.

Office lighting affects the appearance of the space and its occupants, and therefore their mood and productivity.

Naturally, lighting should provide good visibility for the visual tasks.

The Basic Concepts



g

General Lighting
provides the basic light for
any office space.



t

Task Lighting
is the most important office lighting
system—often the primary light source
for office activity.



a

Accent Lighting
brings offices to life—highlights
pictures and other objects.



p

Perimeter Lighting
brightens the walls, making the
space appear larger than it is.

Office Lighting Design Issues

OFFICE LIGHTING DESIGN ISSUES

Open Plan Office, Intensive VDT Use

- Direct glare
- Illuminance (Vertical)
- Luminances of Room Surfaces
- Reflected Glare
- Source/Task/Eye Geometry

Private Office

- Daylighting Integration and Control
- Direct Glare
- Luminances of Room Surfaces
- Reflected Glare

Conference Rooms

- Appearance of Space and Luminaires
- Direct Glare
- Modeling of Faces or Objects

Video Conferencing

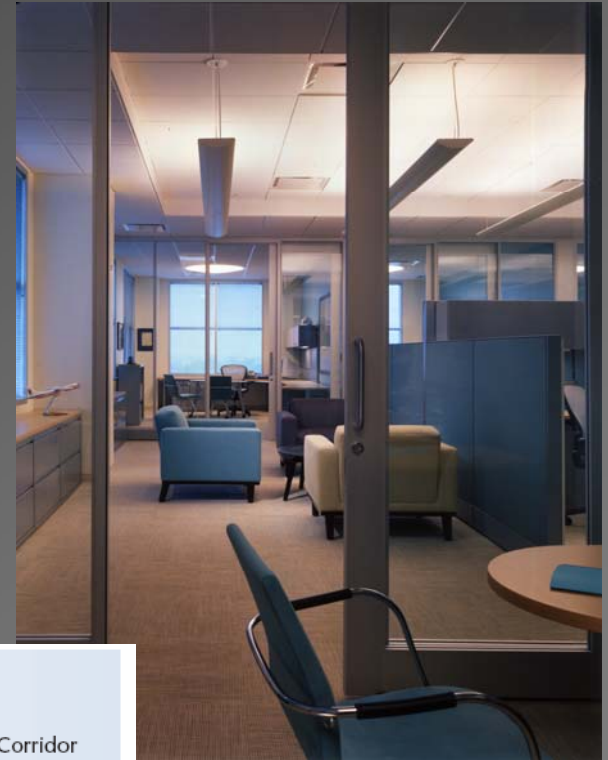
- Direct Glare
- Illuminance (Vertical)
- Modeling of Faces or Objects
- Reflected Glare
- Source/Task/Eye Geometry

Drafting Areas

- Color Appearance (and Color Contrast)
- Direct Glare
- Flicker (and Strobe)
- Illuminance (Horizontal)
- Illuminance (Vertical)
- Light Distribution on Surfaces
- Luminances of Room Surfaces
- Reflected Glare
- Shadows
- Source/Task/Eye Geometry



Office Lighting Design Issues



QUALITY ISSUES FOR OFFICE LIGHTING

	Private Offices	Open-plan Offices	Office Corridor
Control of direct and reflected glare	●	●	○
Light on walls and ceilings	●	●	◐
Physical relation of fixtures to users	●	●	○
Uniformity / Reduce shadows and flicker	◐	◐	○
Room surface characteristics	◐	◐	◐
Color rendering and color temperature	◐	◐	○
Daylighting	◐	◐	○
Lighting controls	◐	◐	○
Quantity of light on task (footcandles)	40-50 fc	40-50 fc	5-10 fc

● Very Important ◐ Important ○ Somewhat Important

* Adapted from the Lighting Design Guide.
IESNA Lighting Handbook, 9th Edition

Educational Facility Design Issues

EDUCATIONAL FACILITY DESIGN ISSUES

Classrooms

- Color Appearance (and Color Contrast)
- Daylighting Integration and Control
- Direct Glare
- Light Distribution on Task Plane (Uniformity)
- Luminances of Room Surfaces
- Reflected Glare
- Source/Task/Eye Geometry

Corridors

- Daylighting Integration and Control
- Direct Glare
- Illuminance (Vertical)
- Light Distribution on Surfaces
- Modeling of Faces or Objects
- Point(s) of Interest

Gymnasiums

- Direct Glare
- Illuminance (Horizontal)
- Illuminance (Vertical)
- Light Distribution on Surfaces
- Light Distribution on Task Plane (Uniformity)
- Reflected Glare
- Shadows

Lecture Halls

- Illuminance (Horizontal)
- Illuminance (Vertical)
- Light Distribution on Task Plane (Uniformity)

Libraries

- Direct Glare
- Illuminance (Horizontal)
- Illuminance (Vertical)
- Light Distribution on Surfaces
- Light Distribution on Task Plane (Uniformity)
- Reflected Glare
- Color Appearance (and Color Contrast)
- Source/Task/Eye Geometry

Science Laboratories

- Color Appearance (and Color Contrast)
- Daylighting Integration and Control
- Direct Glare
- Illuminance (Horizontal)
- Illuminance (Vertical)
- Light Distribution on Task Plane (Uniformity)
- Reflected Glare
- Shadows
- Source/Task/Eye Geometry

Educational Facility Design Issues

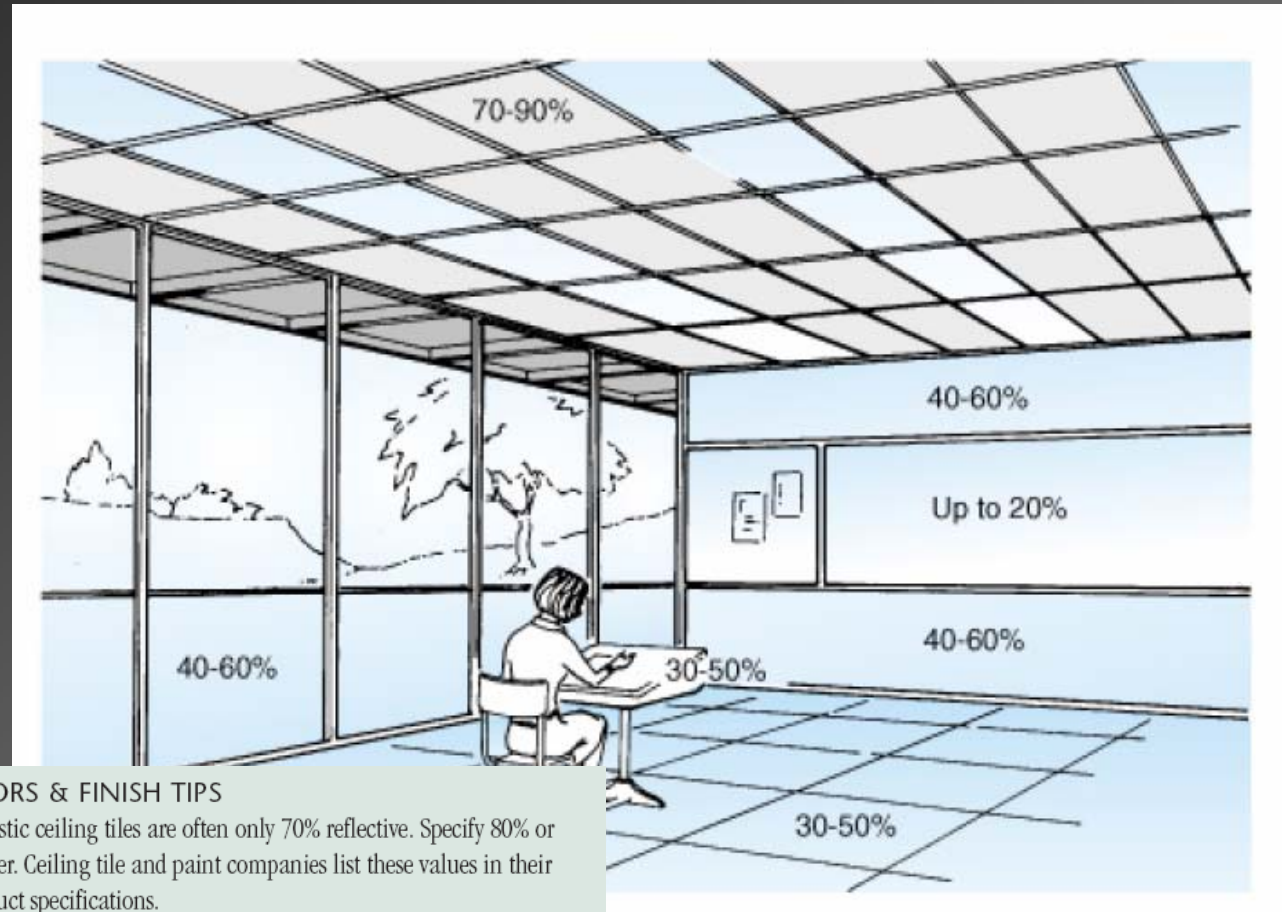


QUALITY ISSUES FOR SCHOOL LIGHTING

	General Classroom	Computer Classroom	School Corridor
Light on walls and ceilings 1 on photo above	●	●	●
Control of direct and reflected glare 2	●	●	○
Uniformity 3	●	●	○
Daylight 4	●	○	●
Color rendering and color temperature	●	●	●
Lighting controls	●	●	○
Quantity of light (horizontal footcandles)	40-50 fc	20-40 fc	10 vert. fc

● Very Important ● Important ○ Somewhat Important * Adapted from the Lighting Design Guide, IESNA Lighting Handbook, 9th Edition

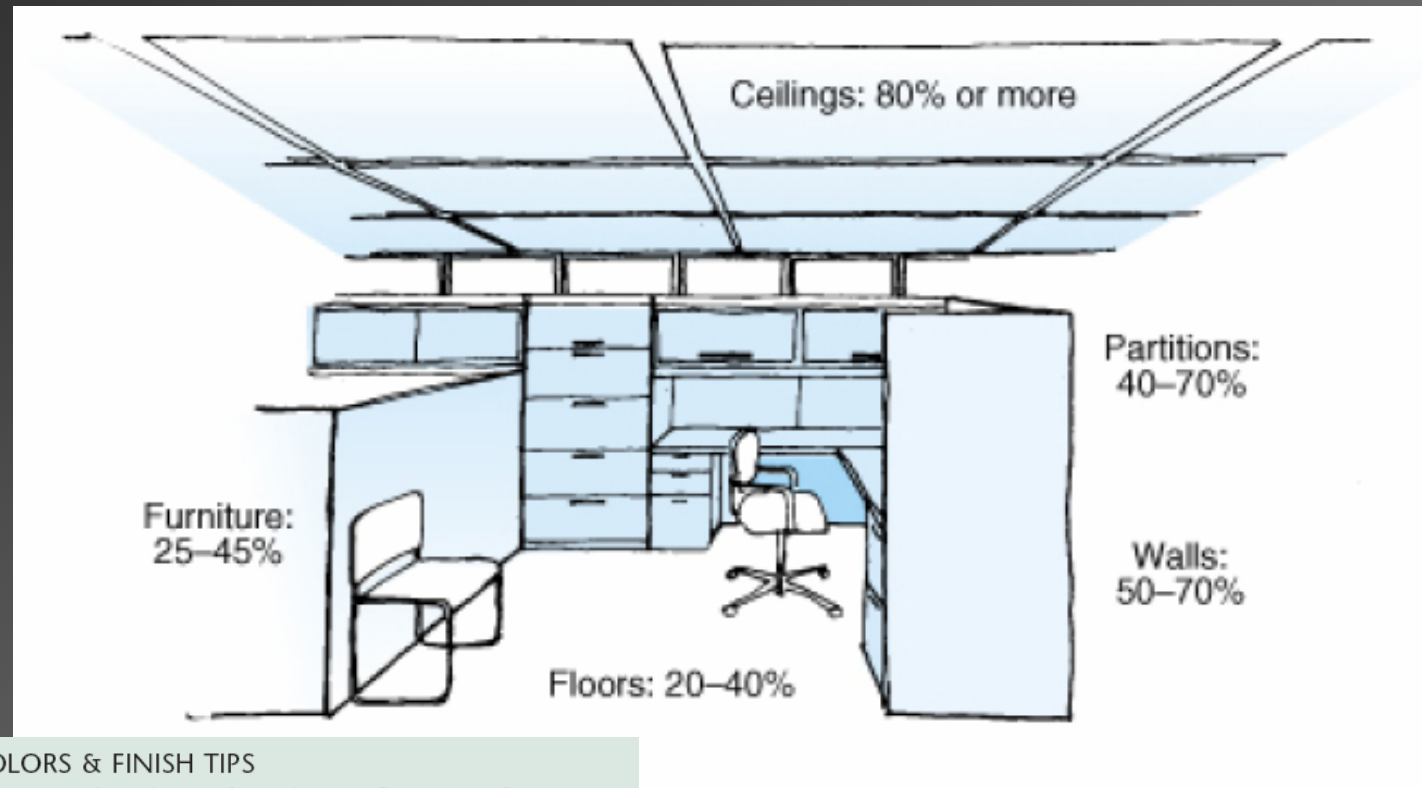
Room Reflectance: Classroom



COLORS & FINISH TIPS

- Acoustic ceiling tiles are often only 70% reflective. Specify 80% or higher. Ceiling tile and paint companies list these values in their product specifications.
- Choose wall colors that are light in color (pastels) and at least 65% reflective.
- Choose furniture that is light in color (60% or higher).
- Always use matte (not shiny or high gloss) surface finishes for walls, ceilings, and furniture.
- Limit the use of primary or saturated colors to accents or wainscots, since they absorb a lot of light.

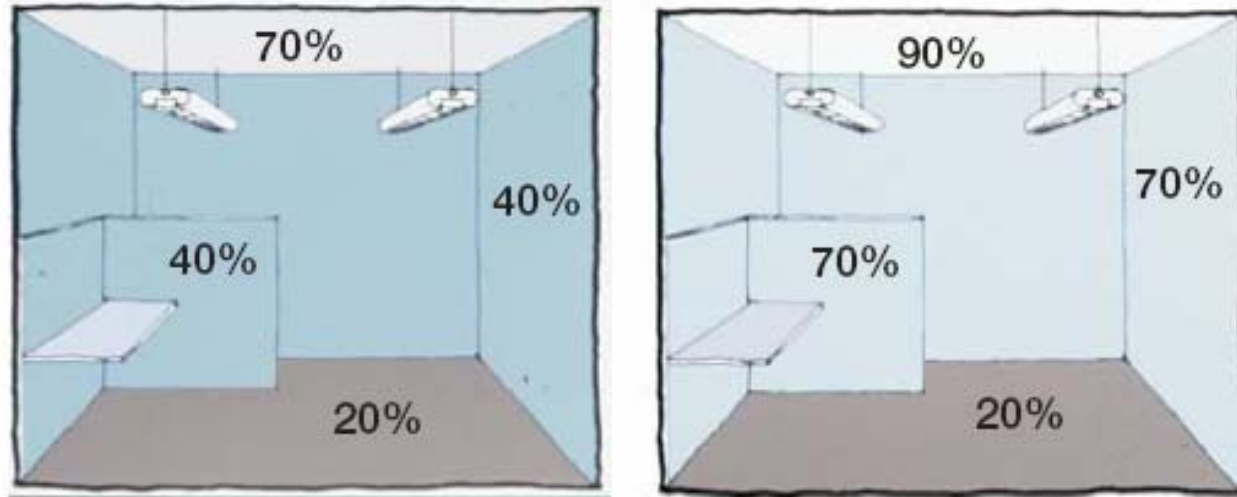
Room Reflectance: Office



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Room Reflectance



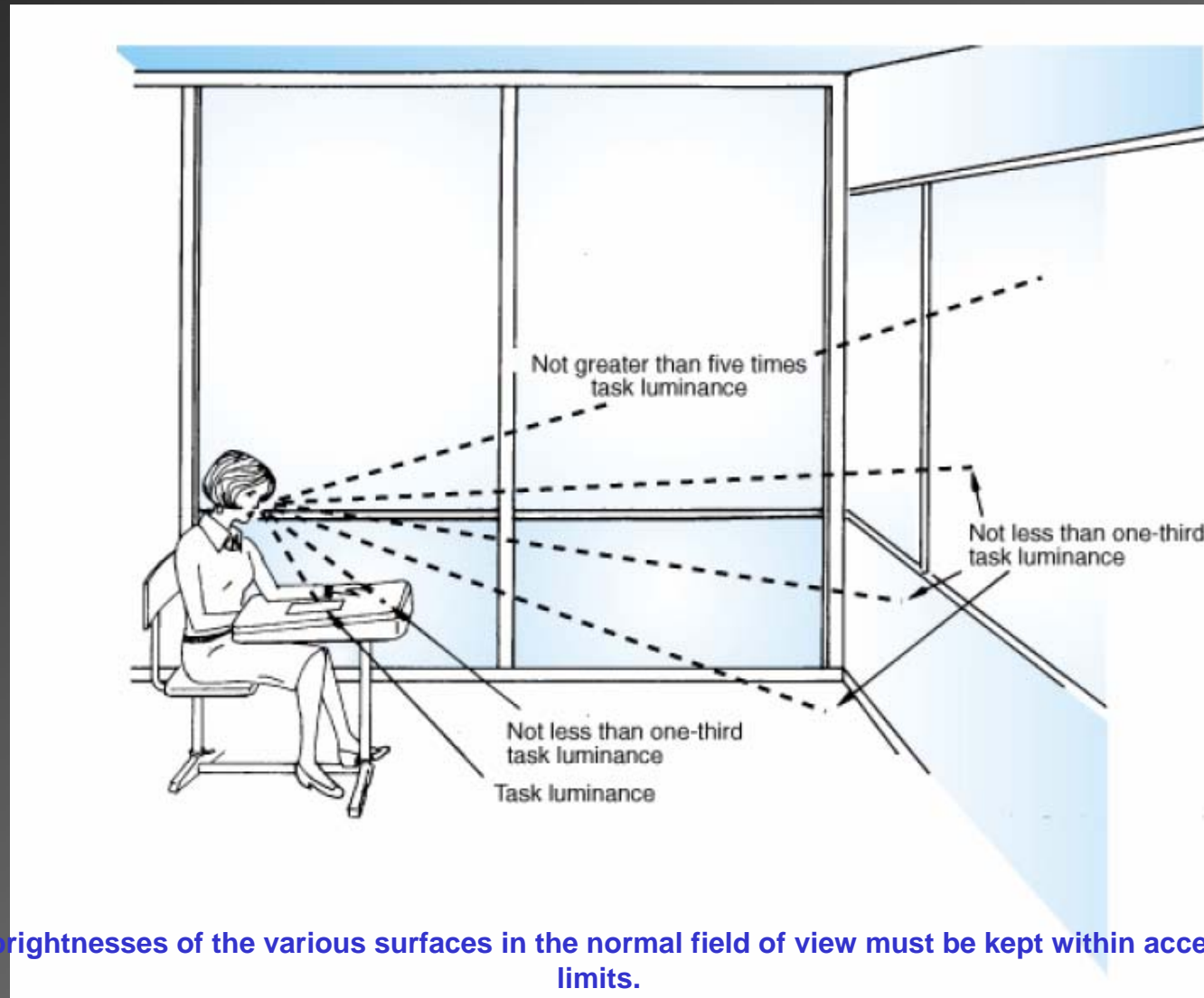
A small increase in room reflectances produces a big improvement in efficiency. The lighter room provides 55% more light on the work surface for the same energy or uses 70% less energy to provide equivalent brightness. The lighter room also provides better brightness ratios, comfort and daylight distribution.







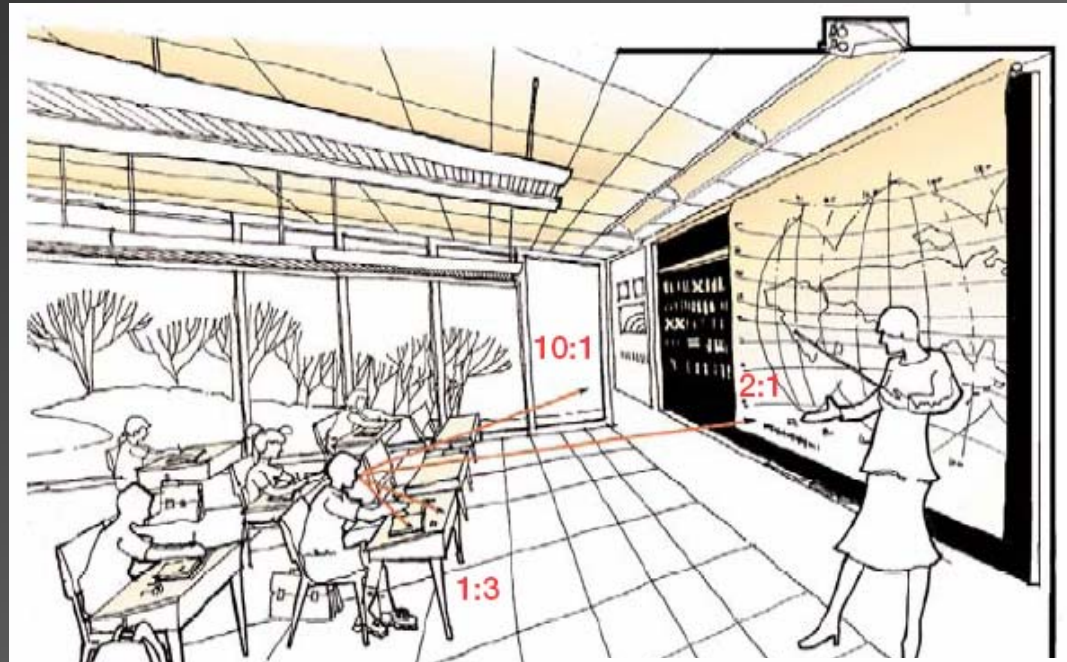
Luminous Ratios: Classroom



The brightnesses of the various surfaces in the normal field of view must be kept within accepted limits.

When the eye fixates on a task, an adaptation level is established. As the eye shifts from one luminance, such as for a book, to another luminance, such as for the chalkboard, it must adapt to the new level. If there is much difference between the two levels, a period of time is required for the eye to adjust itself to the new situation, which can slow visual performance. Further, if the difference is great, discomfort and fatigue can be experienced.

The Classroom (*seminar or lecture room*)



CREATE BALANCED BRIGHTNESS

Light levels throughout the classroom should not differ greatly from the light level on the desks. Large variations in brightness will cause distraction and fatigue.

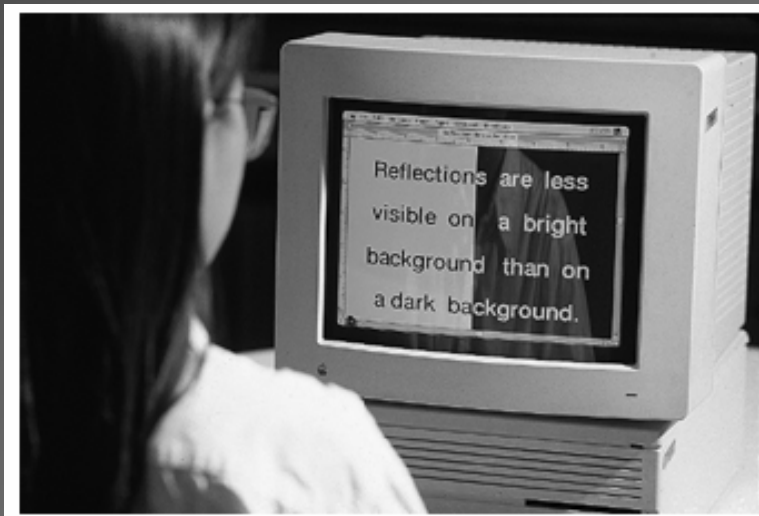
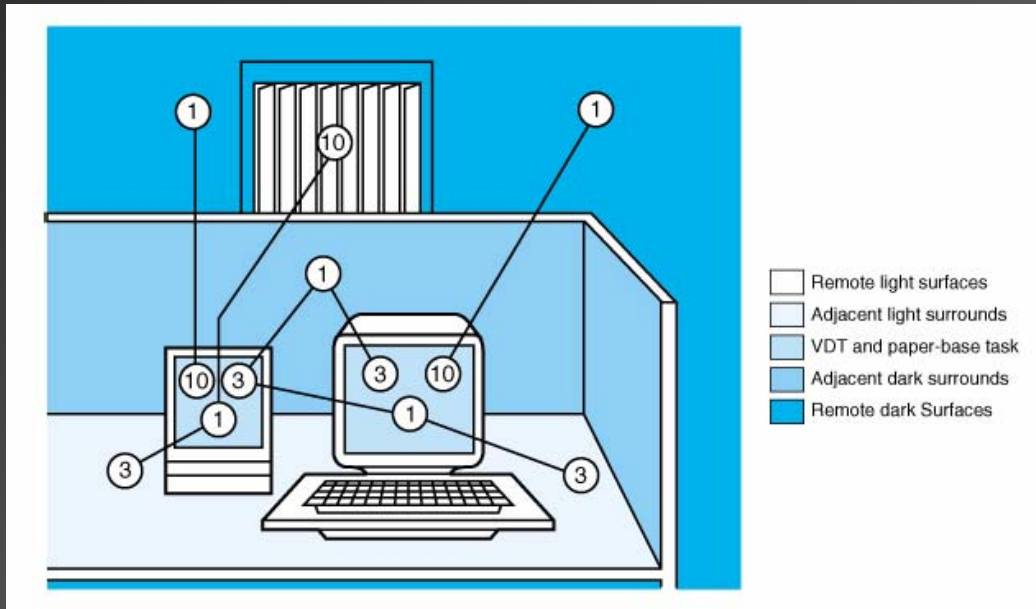
- Use pendant light fixtures that direct at least 50% of the light upward.
- Avoid high contrast. The brightest and darkest room surfaces should be no greater than 3 times or $1/3$ as bright as the task (preferred) or 10 times or $1/10$ as bright as the task (maximum).
- For best student concentration, the brightest surfaces should be desk tops and focal walls.
- Use only semi-specular or white louvers to prevent harsh wall patterns.

ACCENT FOCAL WALLS

The brightest surfaces should be the most important surfaces. Lighting the focal walls helps teachers catch and hold students' attention as well as to improve the visibility of information.

- For rooms where desks face one direction, provide focal lighting on the front wall or board.
- For multi-purpose spaces, provide focal lighting on two or three walls.
- Dedicate light fixtures (such as Type H, J, K) to accent these surfaces.
- Light levels on boards or focal walls should be at least equal to light levels on the desktop, or up to twice that level if the board is green or black. For uniformity, the edges of the board should not be less than $1/3$ the brightness of the center.
- Locate fixtures 1 to 3 feet from the board or vertical surface so that light reflections do not obscure information on the board.

Luminous Ratios: Computer Workstation



Glare



Direct glare from windows and luminaries.

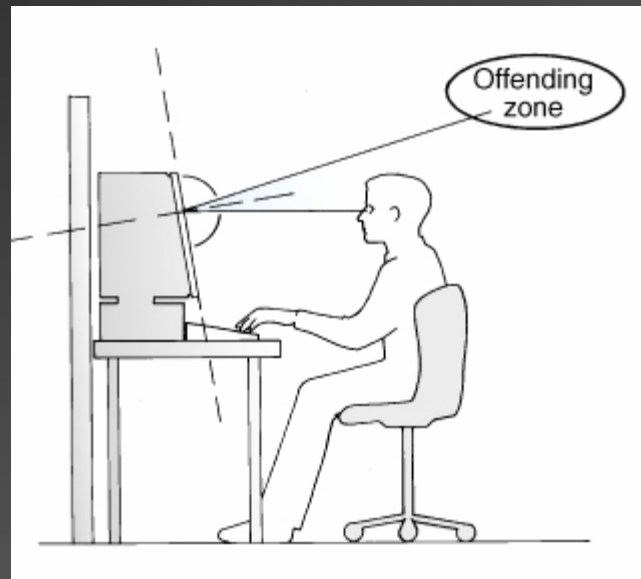


Reflected glare on computer screen from ceiling luminaries.

GLARE PREVENTION TIPS

- Distribute light to walls and ceilings. Bi-directional fixtures such as A, D, and E (see p. 7) work well.
- Use daylight to light walls and ceilings.
- Use adjustable blinds or shades that control window glare while retaining view.
- Choose higher reflectance room surfaces.
- Select only semi-specular or white painted louvers and reflectors. Avoid mirrored or specular (shiny) reflectors or louvers that can be seen from any angle.
- Shield the lamp from view with baffles, louvers, lenses or diffusing overlays.
- Use lamps of lower brightness. Use more fixtures if necessary.
- Only use T5, T5HO and T5 biaxial lamps in coves or indirect applications where the lamp is not visible by classroom users.
- Use no more than three (3) T8 lamps in 2' x 4' fixtures.

Glare



Angle from Vertical (deg.)	Average Luminance (cd/m ²)*	
	Preferred	Maximum
55	850	—
65	350	850
75	175	350
≥85	175	175

* Luminance is measured along the lengthwise, cross-wise, and 45° horizontal planes.



Energy Codes

POWER LIMITS From ANSI/ASHRAE/IESNA Standard 90.1-1999

	Watts / SF		Watts/SF
Private Offices	1.5	School / University	1.5
Open Plan Offices	1.3	Library	1.5
Office Corridor	0.7	Cafeteria	1.8
Reception/Lobby	1.8		
Conference/Meeting	1.5		
Active Stairs	0.9		
Active Storage	1.1		

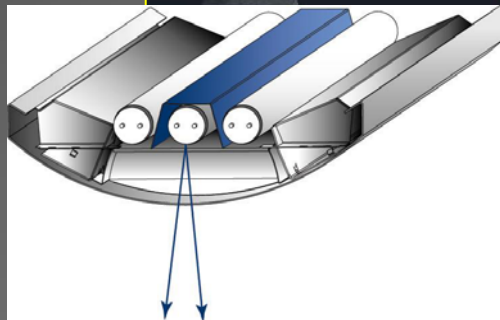
MATCH CONTROLS TO ROOM TYPES

	General Classroom	Computer Classroom	School Corridor	Potential Energy Savings *
Ceiling Occupancy Sensor, Manual-On, Auto-Off	●	●	○	30%
Multi-Level Switching with Ceiling Occupancy Sensor	●	●	○	35%
Daylight Controls with Occupancy Sensor	●	◐	◐	45%
Multi-Level Switching	●	●	◐	15%
Building Time Controls	◐	◐	◐	10%

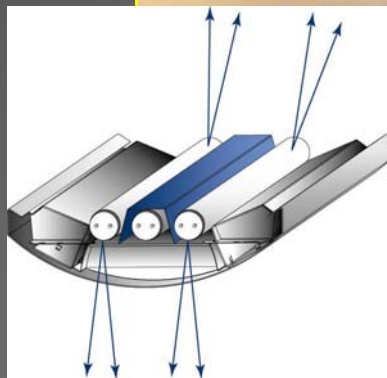
● Appropriate ◐ Sometimes Appropriate ○ Not Appropriate

* As compared to standard manual switching for a 5,000 sq. ft. building with a 1.2 watts per sq. ft. connected load.

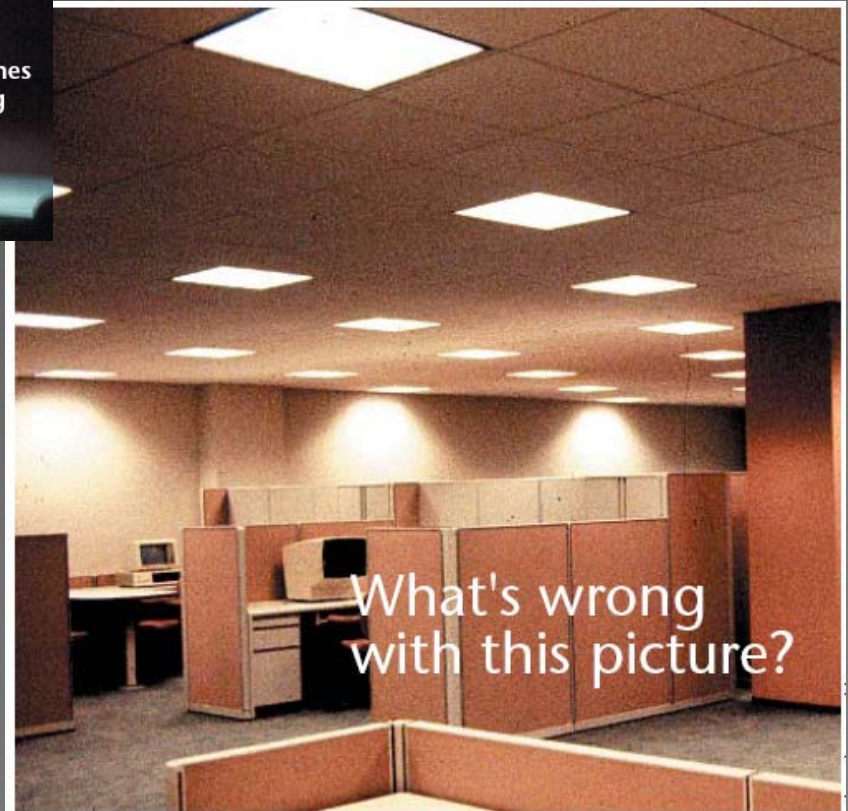
Lamp Control



Lamp Control



The Problem with Standard Lighting



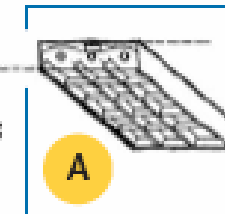
Avoid staggered layouts and locating fixtures too close to walls.

The Office Troffer

A. 2' x 4' THREE-LAMP PARABOLIC TROFFER

LAMPS: (3) 32W T8, 835 color

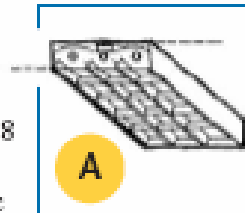
DESCRIPTION: Recessed fluorescent troffer 2' by 4' with white baked enamel interior, semi-specular low-iridescent parabolic louvers with 18 cells, minimum 2-3/4" deep. Use white painted louvers in private offices. Three-lamp electronic instant-start ballast, nominal 91 input watts. 71% minimum fixture efficiency. Note: 3-lamp or 2-lamp ballasts with inboard-outboard switching and tandem wiring.



A. 2' x 4' THREE-LAMP PARABOLIC TROFFER

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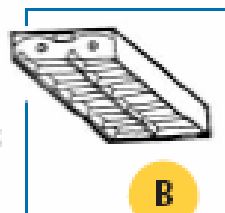
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B. 2' x 4' TWO-LAMP PARABOLIC TROFFER

LAMPS: (2) 32W T8, 835 color

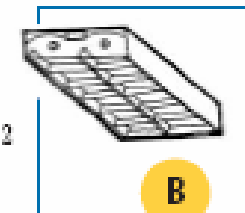
DESCRIPTION: Recessed fluorescent troffer 2' by 4' with white baked enamel interior, semi-specular low-iridescent parabolic louvers with 12 cells, minimum 2-3/4" deep. Use white painted louvers in private offices. Two-lamp electronic instant-start ballast, nominal 61 input watts. 73% minimum fixture efficiency.



B. 2' x 4' TWO-LAMP PARABOLIC TROFFER

LAMPS: (2) 32W T8, 835 color

DESCRIPTION: Recessed fluorescent troffer 2' by 4' with white baked enamel interior, semi-specular low-iridescent parabolic louvers with 12 cells, minimum 2-3/4" deep. Use white painted louvers in private offices. Two-lamp electronic instant-start ballast, nominal 61 input watts. 73% minimum fixture efficiency.



Better



Better



better yet

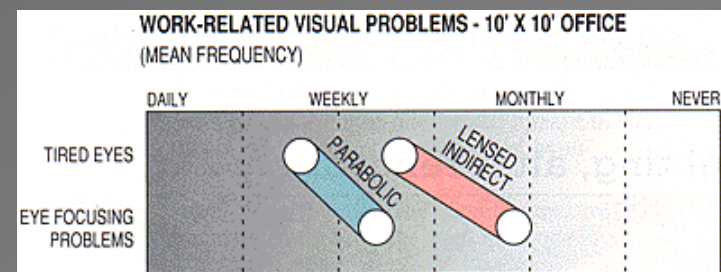
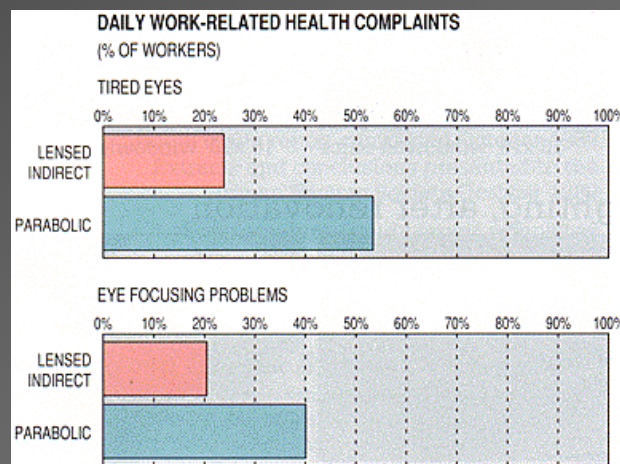
Direct versus Indirect



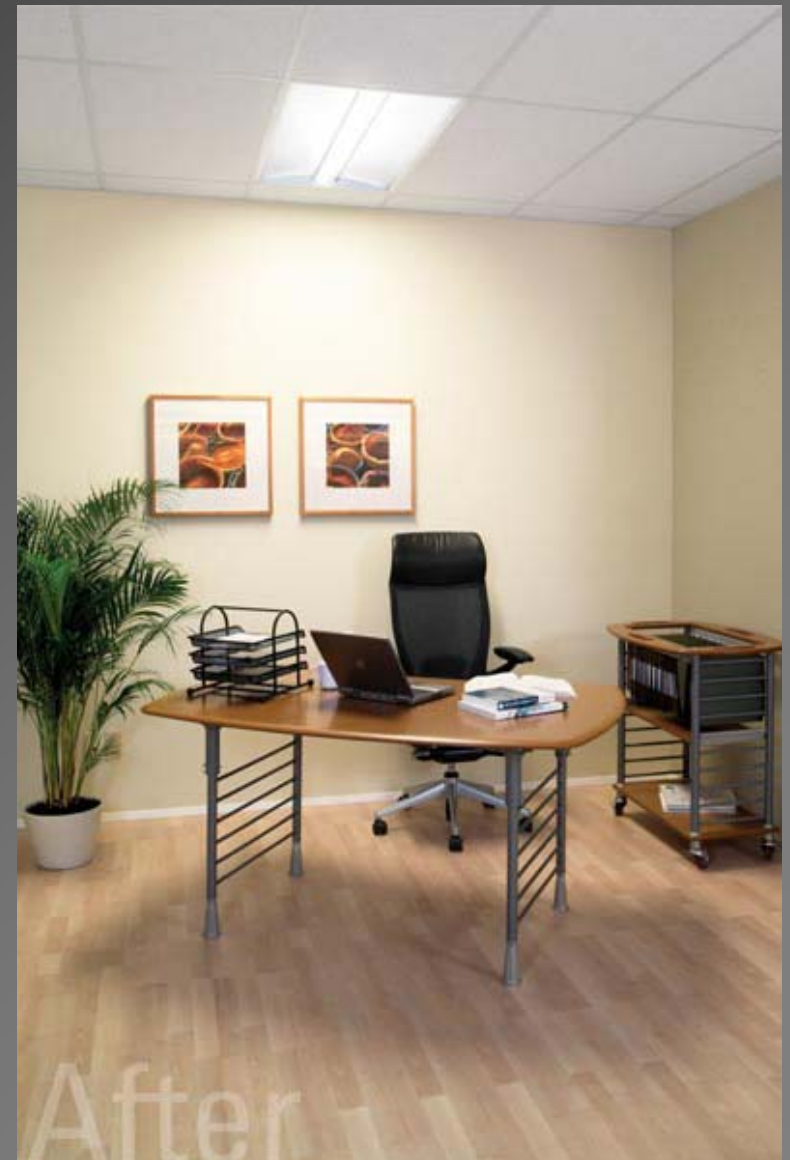
In the last decade, during which personal computers have proliferated in the office, researchers have paid increased attention to lighting. Several studies have investigated the relationship of modern office lighting to the visual health, satisfaction and productivity of office workers.

- The American Society of Interior Designers found that 68% of employees complain about the light in their offices.
- A Silicon Valley study pointed out that 79% of VDT users want better lighting.
- A 1989 Louis Harris survey, the Steelcase Office Environment index, revealed that workers think of eyestrain as the number one health hazard in the office—ahead of radiation, asbestos, even exposure to AIDS.

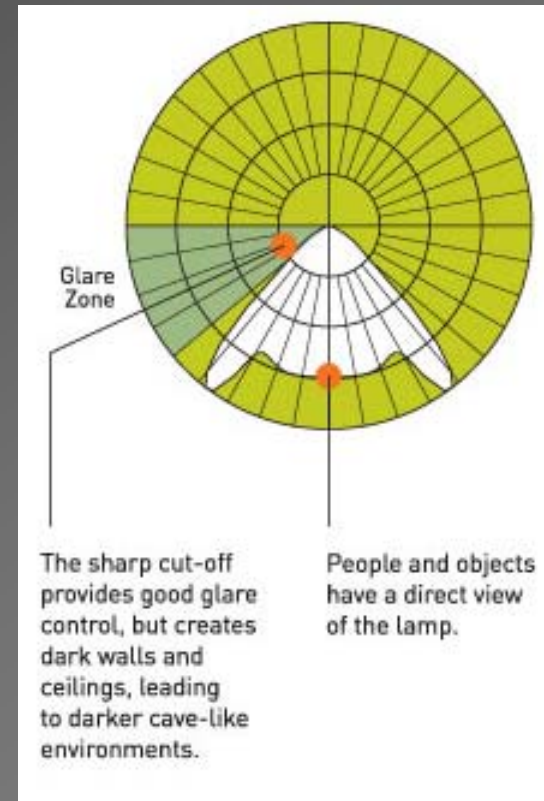
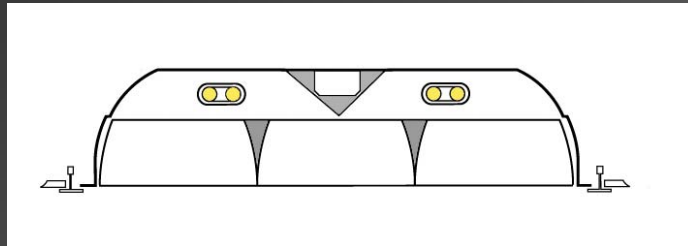
This degree of dissatisfaction is difficult to ignore. It confirms the need to identify the best methods of lighting the computerized office.



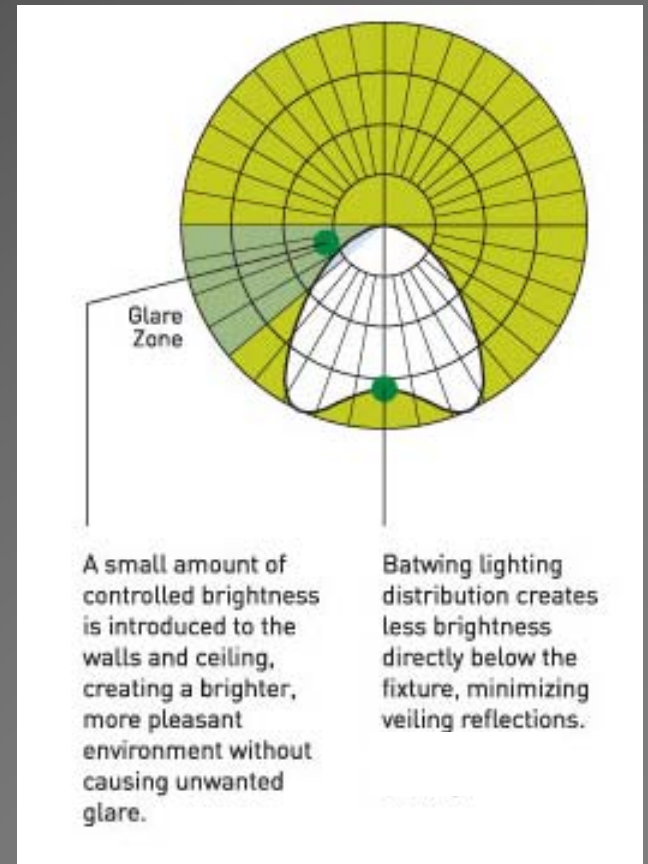
Direct Distribution: Troffer



Direct Distribution: Troffer



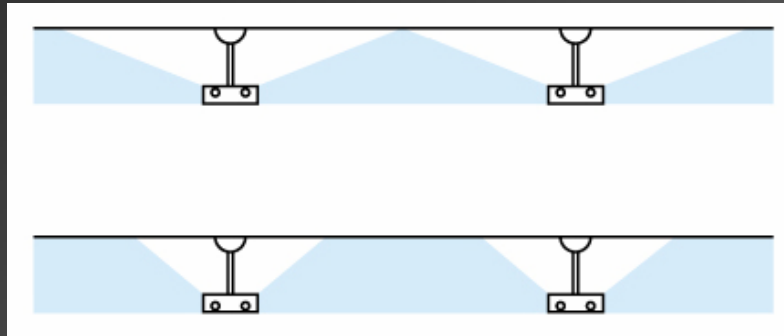
Direct Distribution: Alternate Toffers



A small amount of controlled brightness is introduced to the walls and ceiling, creating a brighter, more pleasant environment without causing unwanted glare.

Batwing lighting distribution creates less brightness directly below the fixture, minimizing veiling reflections.

Indirect Distribution: Pendant



Direct Distribution: Pendants



Combination Distribution

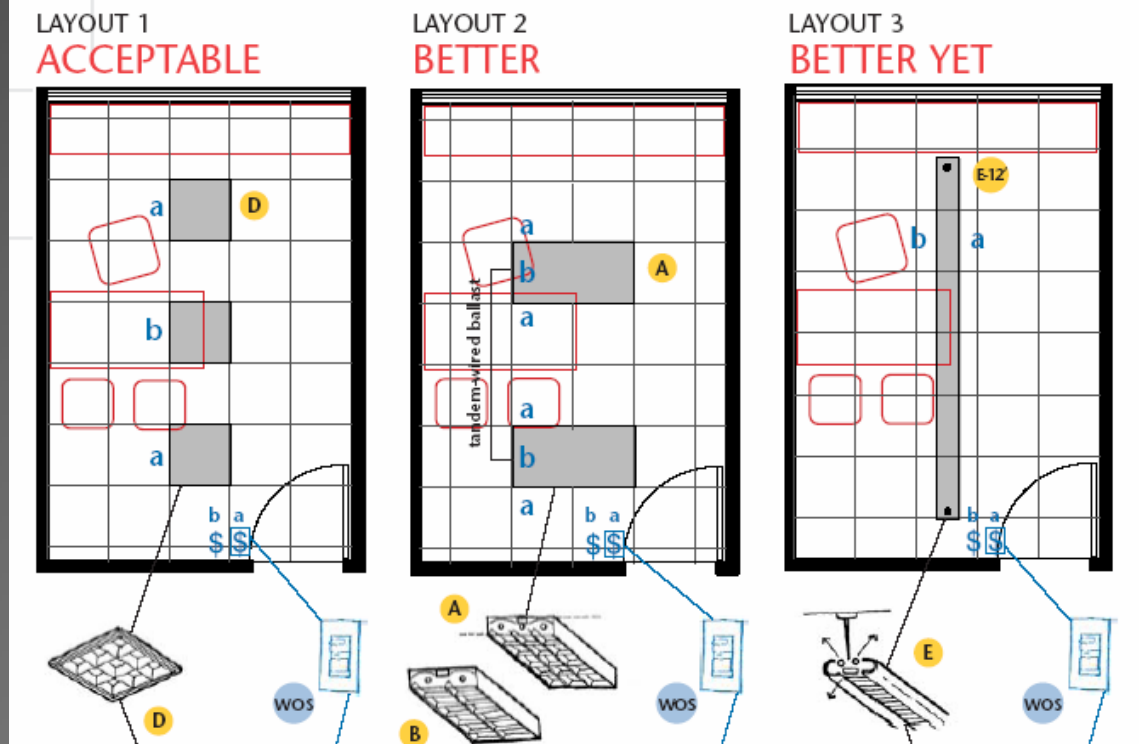


Combination Distribution



Private Office

COMPARISON CHART FOR PRIVATE OFFICES			
	Layout 1	Base Case Layout 2	Layout 3
Uniformity	★★	★★	★★★
Comfort & Quality	★★	★★	★★★★
Maintained Footcandles on Desk (fc)	35-45	45-58	45-50
Ambient Connected Load (W/sf)	1.2	1.2	1.1
Potential Energy Savings ¹ (%)	0-20%	0-20%	10-25%
First Cost Increase ² (material & labor)	+55-65%	Base case	20-30%
Applicable Square Foot Range ³ (sf)	125-150	135-185	115-180
OVERALL VALUE	ACCEPTABLE	BETTER	BETTER YET



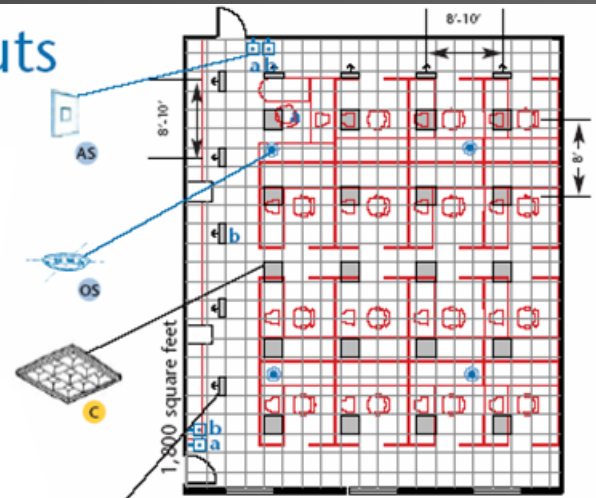
Open Plan

open-plan office layouts

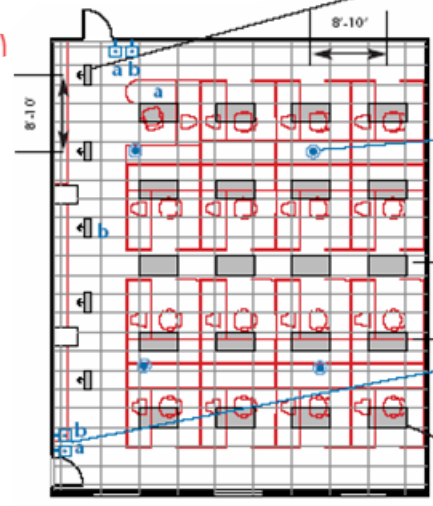
COMPARISON CHART FOR OPEN-PLAN OFFICES

	Layout 7	Layout 8	Layout 9
Uniformity	★★	★★	★★★
Comfort & Quality	★★	★★★	★★★★
Maintained Footcandles on Desk ¹ (fc)	40-45	50-60	50-80
Ambient Connected Load (w/sf)	1.2	1.1	1.0
Potential Energy Savings ² (%)	20-35%	25-40%	30-45%
First Cost Increase ³ (material & labor)	+20-30%	+0-5%	+35-45%
Applicable Square Foot Range ⁴ (sf)	1700-2200	1600-2600	1400-2800
OVERALL VALUE	ACCEPTABLE	BETTER	BETTER YET

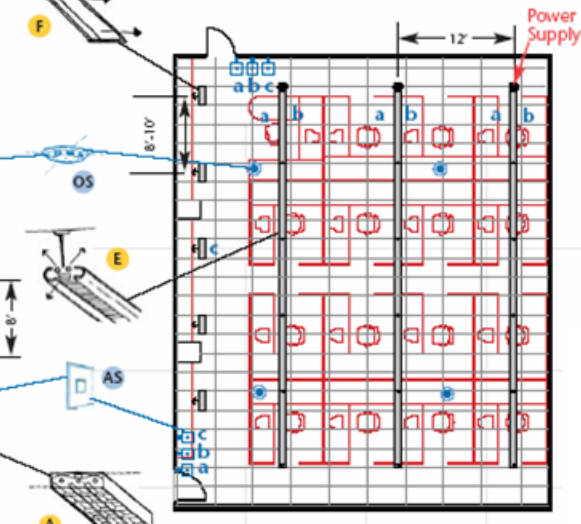
QUICK TIP: Actual footcandles at the desk will be 15 to 20% lower if furniture partitions taller than 54" are used. Furniture-mounted overhead storage bins further reduce light levels. If bins are used, consider providing fewer footcandles from the ceiling and providing local task lighting



LAYOUT 7
ACCEPTABLE 2'x2' ceiling grid



LAYOUT 8
BETTER 2'x4' ceiling grid



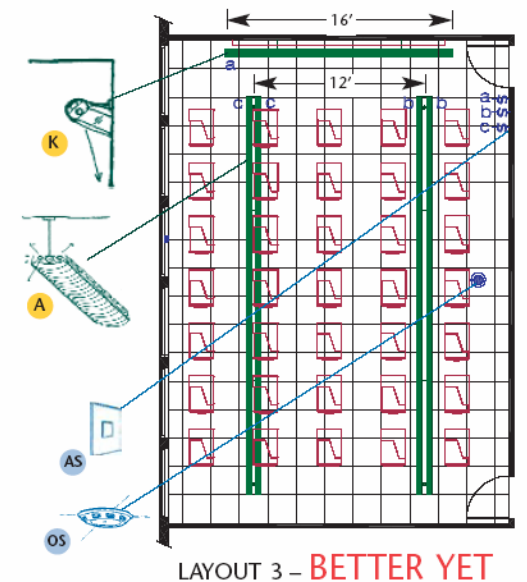
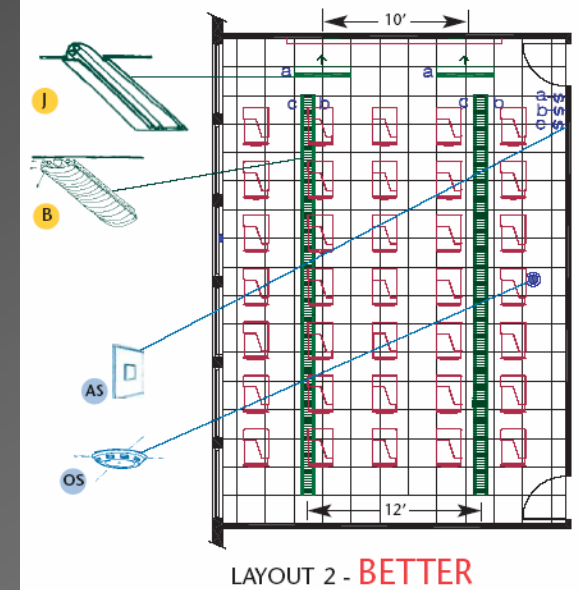
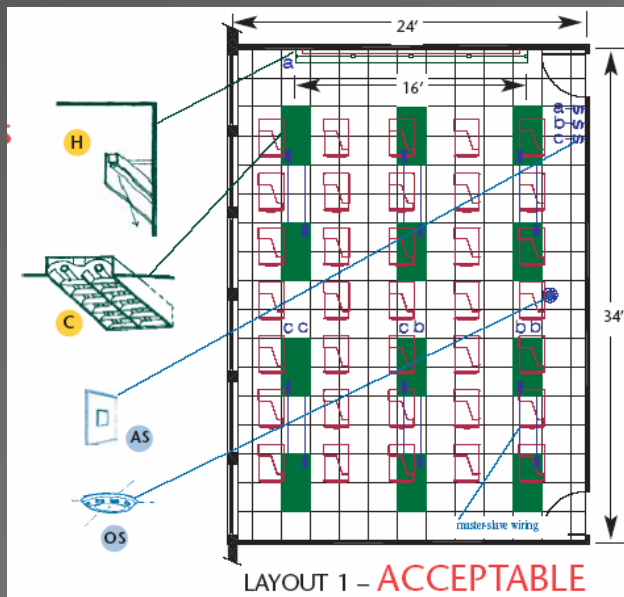
LAYOUT 9
BETTER YET 2'x4' ceiling grid

Classroom

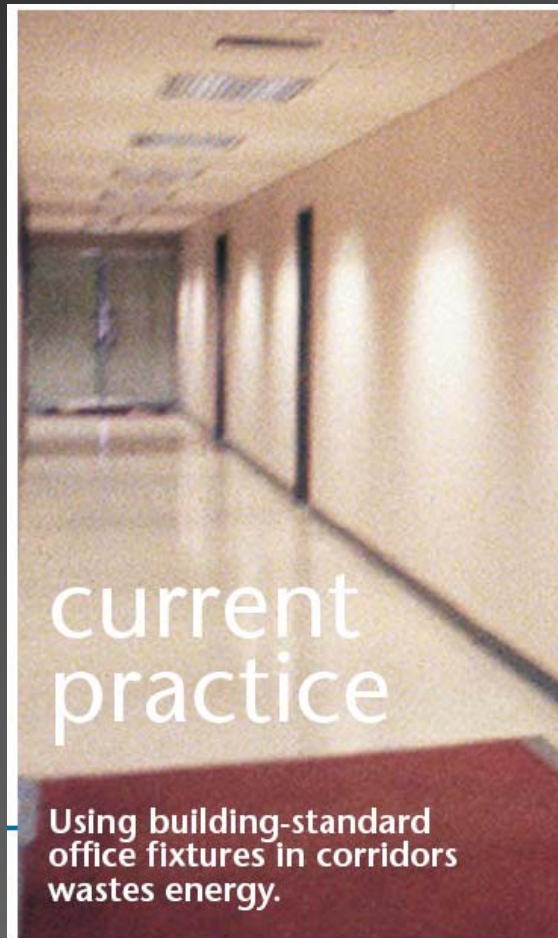
COMPARISON CHART FOR GENERAL CLASSROOMS

For classrooms from 750 to 850 sf.

	Layout 1	Layout 2	Layout 3
Interest	★★	★★★★★	★★★★★
Uniformity	★★	★★★	★★★★★
Comfort & Quality	★★	★★★	★★★★★
Power Density (w/sf)	1.01	1.16	1.16
Energy Savings (Potential %) ²	46%	40%	40%
First Cost (% Increase)	40%	170%	115%
Maintained Footcandles (fc)	45-50	45-50	45-50
OVERALL VALUE	ACCEPTABLE	BETTER	BETTER YET



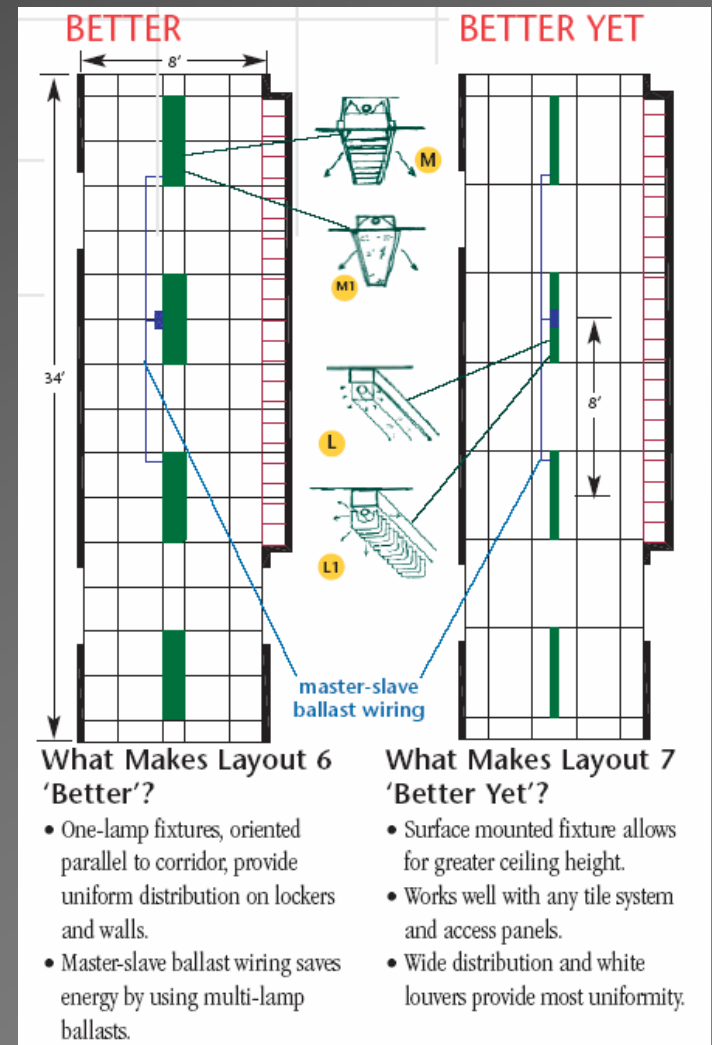
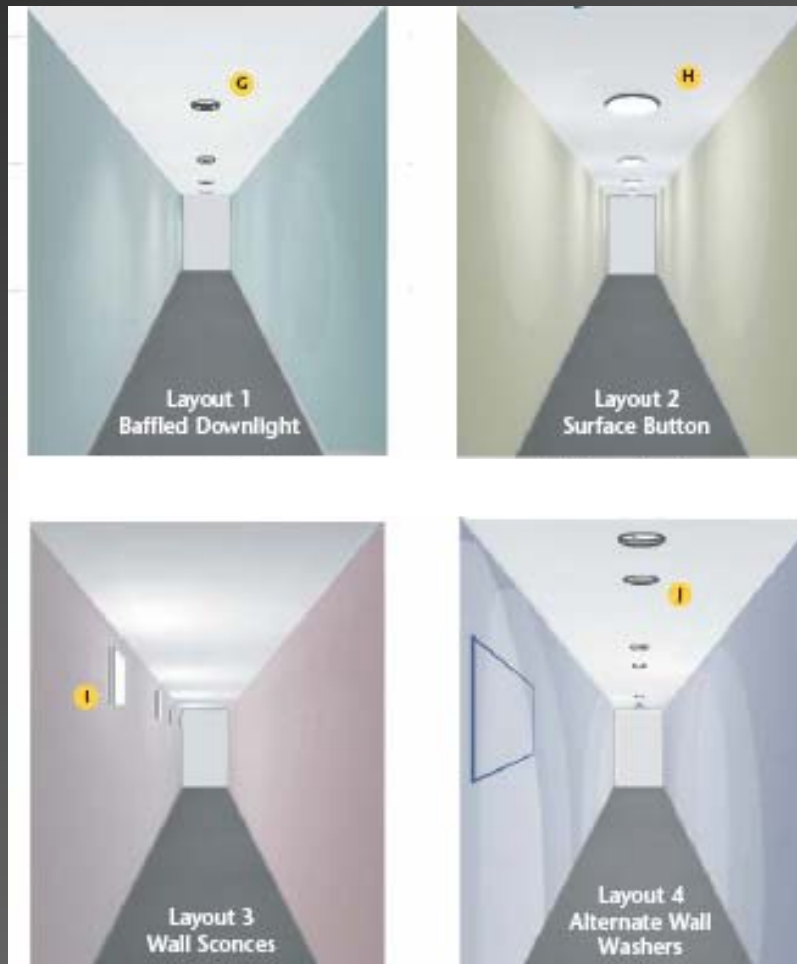
Corridor Lighting



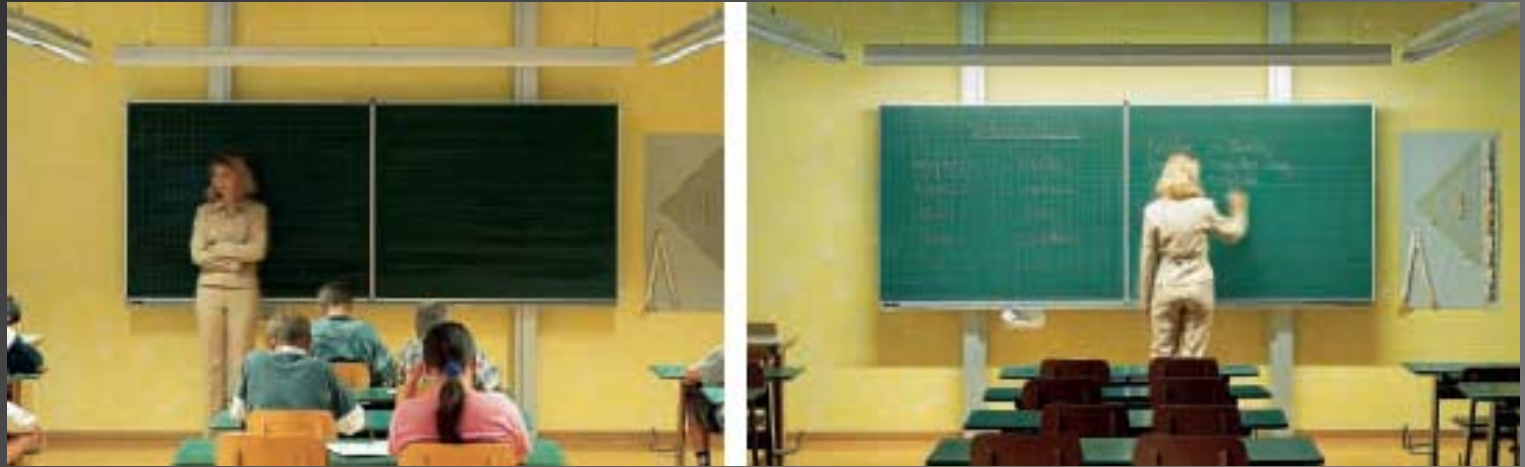
Corridor illumination on the floor should be at least **one-fifth the illuminance of the floor in adjacent areas**. This illuminance is both safe and energy efficient and does not require major visual adaptation upon entering and leaving the corridor.

Wall finish reflectances should equal or exceed those in adjacent areas. Linear luminaires oriented crosswise to the corridor generally make the narrow space appear wider. Continuous linear luminaires located adjacent to the side walls provide high wall brightness and can give a feeling of spaciousness. Corridors, which are paths of egress, must be provided with emergency lighting.

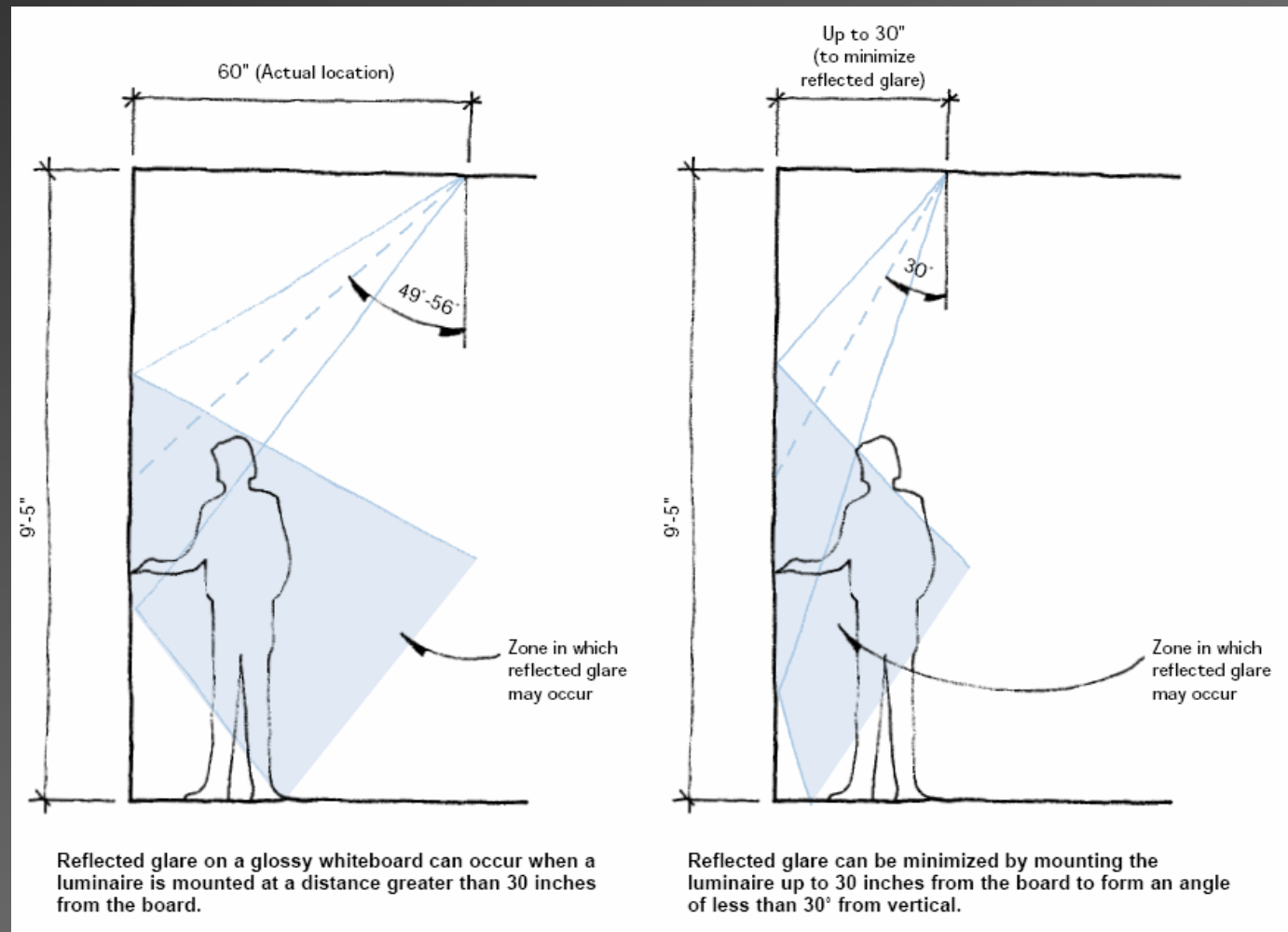
Corridors



Lighting Whiteboards or Vertical Display



Lighting Whiteboards or Vertical Display



Asymmetric Distribution: Pendant



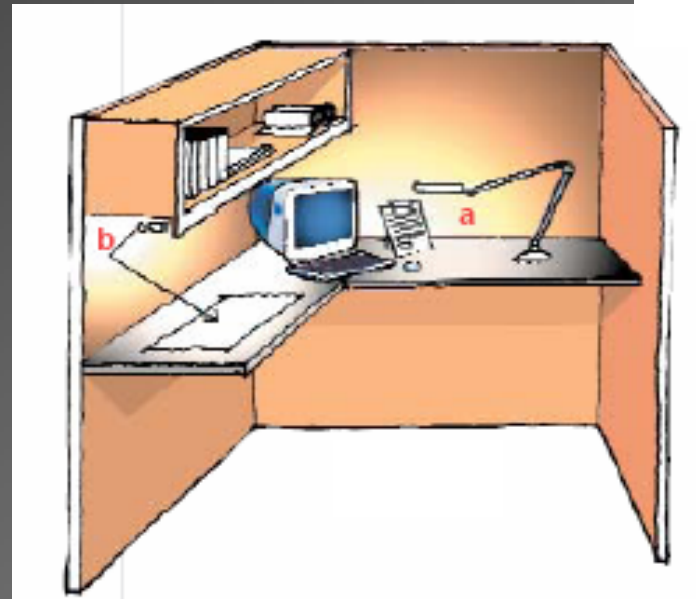
Asymmetric Distribution: Recessed



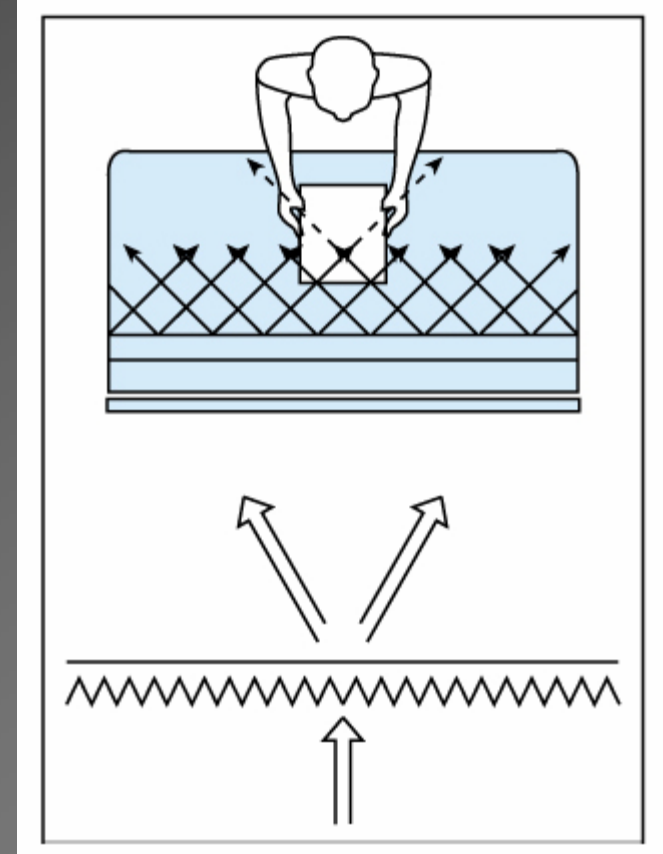
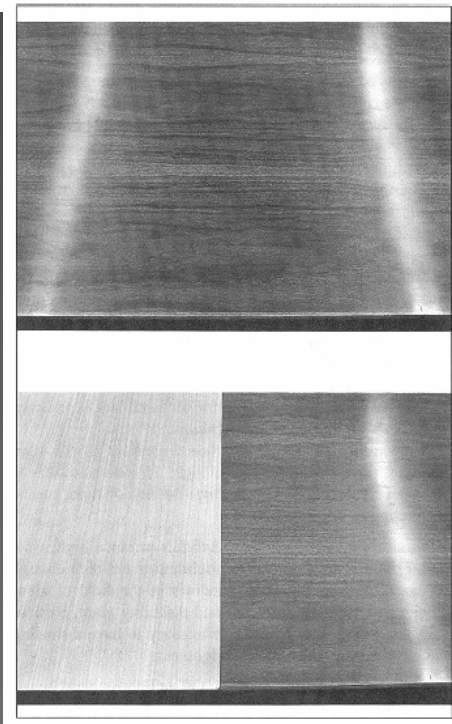
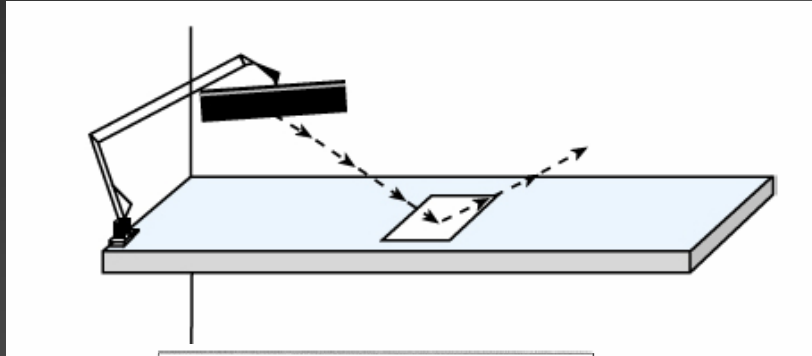
Asymmetric Distribution: Surface (above)



Task Lighting



Task Lighting



Book Stacks

- Bookstacks must be lit adequately so patrons can find books and also so staff can spend long hours shelving books without visual discomfort.
- Evenness of illumination across the stack face is more important than achieving a high lighting level at any single point. More specifically, the lighting level should be no more than a 6-to-1 maximum-to-minimum ratio across the entire stack face.
 - **Reading Stacks – 30fc horizontal** (30in above the floor)
 - **Active Stacks – 30fc vertical** (30in above the floor)
 - **In Active Stacks – 5fc vertical** (30in above the floor)

Approaches to Stack Lighting

Parallel scheme, where rows of linear fixtures are located directly above the stack aisles

Perpendicular scheme, where rows of fixtures run perpendicular to the stacks and stack aisles

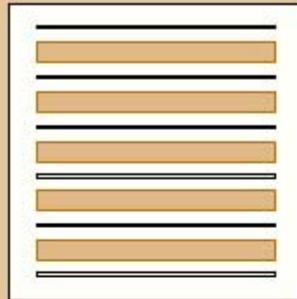
Indirect scheme, where lighting is aimed upward rather than downward, and is bounced off the ceiling. The resulting light is diffuse and non-directional. Therefore, the light fixtures can be arranged in almost any uniform geometry above the stacks.

Book Stacks

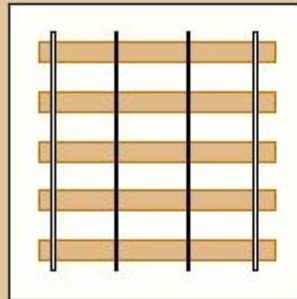


Book Stacks

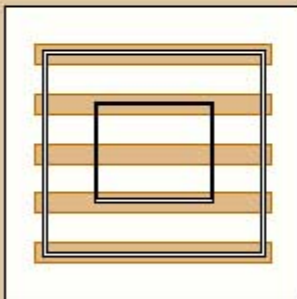
Typical Layout Patterns for Library Stack Areas



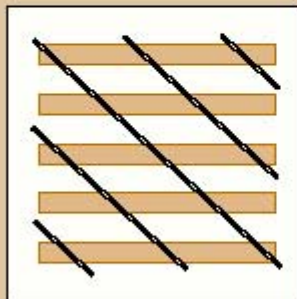
Parallel Pattern



Transverse Pattern
(Perpendicular)

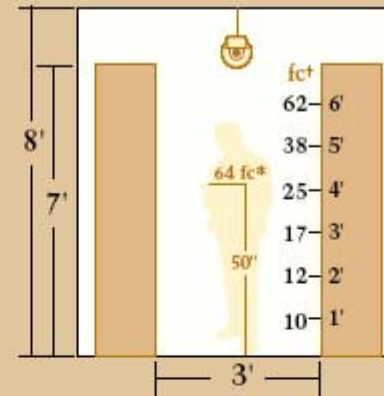


Concentric Pattern



Diagonal Pattern

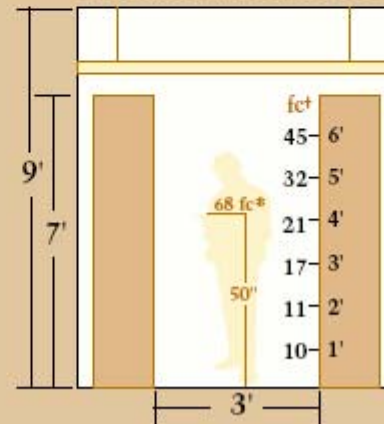
Parallel Pattern Suspended Direct Fixture



Stalite 500[®]
P-D-0528T8
Rows centered along
stack aisles
1-T8 lamp

(maintained fc, LLF=.75)

Transverse Pattern Suspended Indirect/Direct Fixture



LC-93[™]
P-ID-9348T8
Rows mounted
perpendicular
to stacks - 8' OC
2-T8 lamps

(maintained fc, LLF=.75)

+ Vertical Illuminance on shelves (foot-candles)

* Horizontal Illuminance for a reading position

Laboratories



Luminance Recommendations for Laboratories
from 1993 and 2000 IESNA Handbooks (for reference purposes*)

IESNA Lighting Handbook- 9th Edition 2000
Illuminance Maintained (fc)

Specimen collecting	horizontal	50
	vertical	10
Science laboratory	horizontal	50
	vertical	30

Design Guide Section (Interior pg. 4,6,7)

IESNA Lighting Handbook- 8th Edition 1993

Illuminance Maintained (fc) - horizontal

fc Range

Laboratories

Specimen collecting	50 - 75 - 100
Tissue laboratories	100 - 150 - 200
Microscopic reading room	20 - 30 - 50
Gross specimen review	100 - 150 - 200
Chemistry room	50 - 70 - 100

Bacteriology rooms

General	50 - 75 - 100
Reading culture plates	100 - 150 - 200
Hematology	50 - 75 - 100

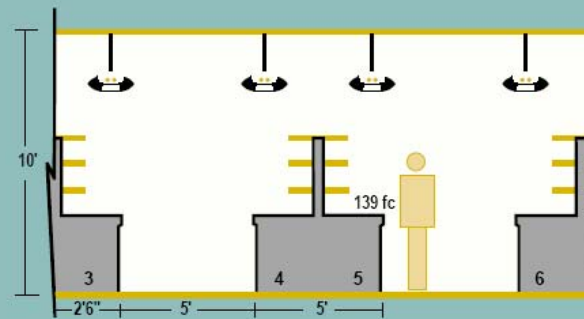
(pg. 461,462)

Laboratories

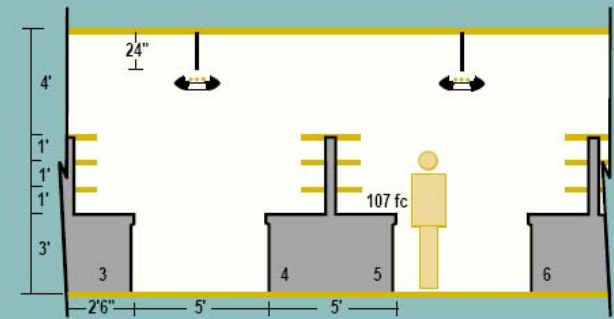


Laboratories

System A with Indirect/Direct Linear Fluorescent Fixtures (mounted over work surfaces)

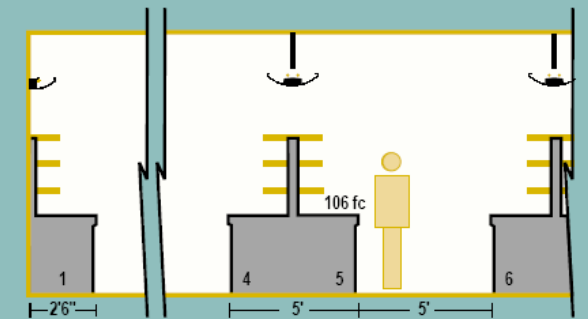


System B with Indirect/Direct Linear Fluorescent Fixtures (mounted between benches)



Data/Layout	Parabolics	A	B	C	
Fixture Position	over work surface	over work surface	between benches	over shelving	wall mounted
Fifth Bench Top Avg. Initial/maint. fc (.75 LLF)	127/95	139/104	107/80	106/80	
Circulation Area (floor)	114/86	109/82	86/65	92/69	
Fixture Type	Direct Recessed	Indirect/Direct Pendant	Indirect/Direct Pendant	Indirect Pendant	Asymmetric Indirect Wall
Description	Parabolic	P-ID-9348T8*	P-ID-9368T8*	P-I-5948T5HO*	W-AI-96P28T5HO*
Lamp Type	F032T8	F032T8	F032T8	F54T5HO	
X-Section Lamps	2	2	3	2	1
Fixtures/Bench	2	2	1	0.5	
Watts/ ft. ²	2.3	2.3	1.7	2.3	
Number of rows	20	20	10	8	4
Total fixtures ¹	80	40	20	16	8
Input Watts ²	60	60	60	122	
Typical fixture cost/ ft.	\$16	\$25	\$30	\$30	\$28
Total Installed cost ³	\$13,102	\$14,347	\$7,973	\$8,806	
Total Installed cost/ ft. ²	\$6.24	\$6.83	\$3.80	\$4.19	
Annual operating cost ⁴	\$864	\$864	\$648	\$878	

System C with Indirect only Linear Fluorescent Fixtures (mounted over shelving and wall-mounted)



Lobbies and Reception



Reception areas are designed for people who are waiting for their appointments and, while waiting, reading or conversing with others. The lighting should be restful and yet provide enough illumination for reading.

One way to provide a restful atmosphere without direct glare is by illuminating one or more of the walls. Another way is to light the ceiling and part of the walls. Accent lighting for pictures or for a piece of sculpture enlivens the appearance of the room. If there is a receptionist located in the area, the ambient illumination may need to be augmented, depending on the visual tasks involved. Care should also be taken to illuminate the receptionist's face, so as to make this person look approachable, and also to eliminate harsh shadows caused by the downlights directly overhead. Task lighting can be provided for people waiting in the reception area.