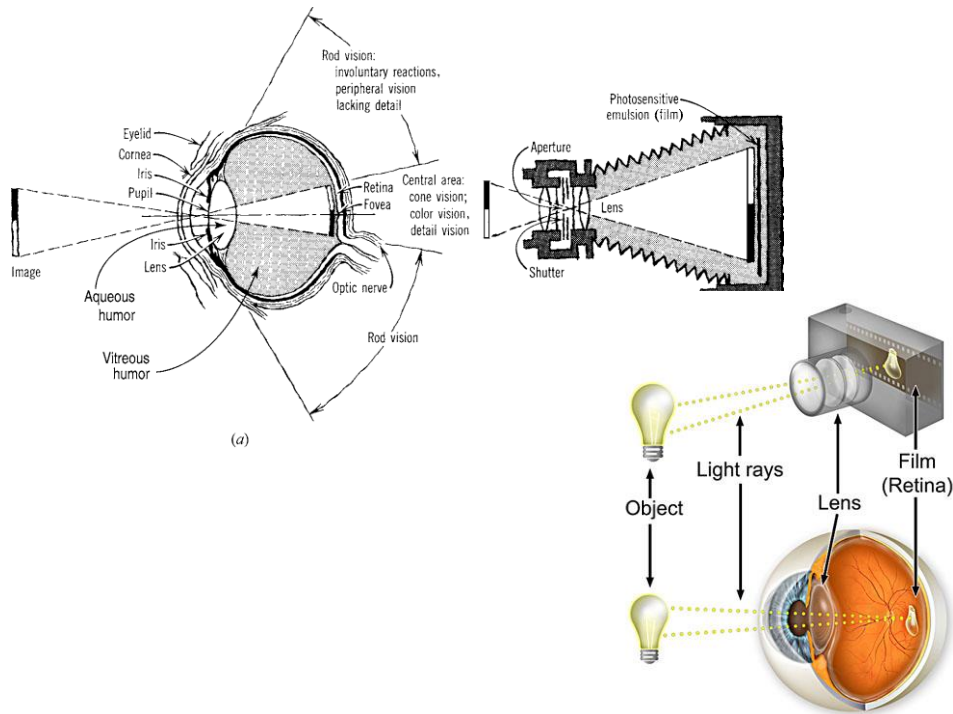


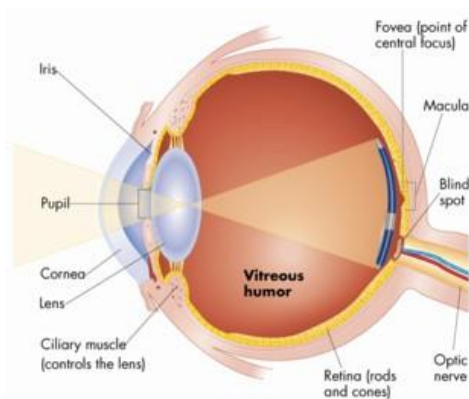
Light and sight

Sight is the ability for a token to "see" its surroundings

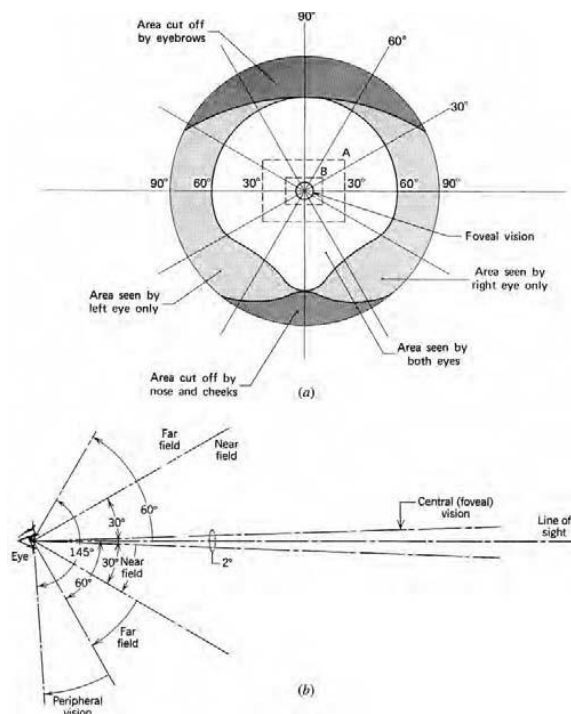
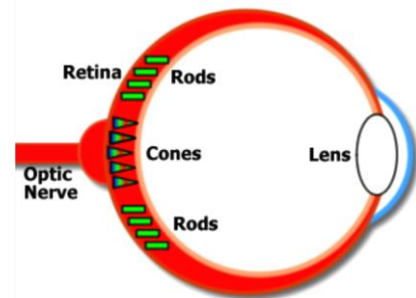
Light is a feature that allows tokens and objects to cast "light" over a certain area, illuminating it



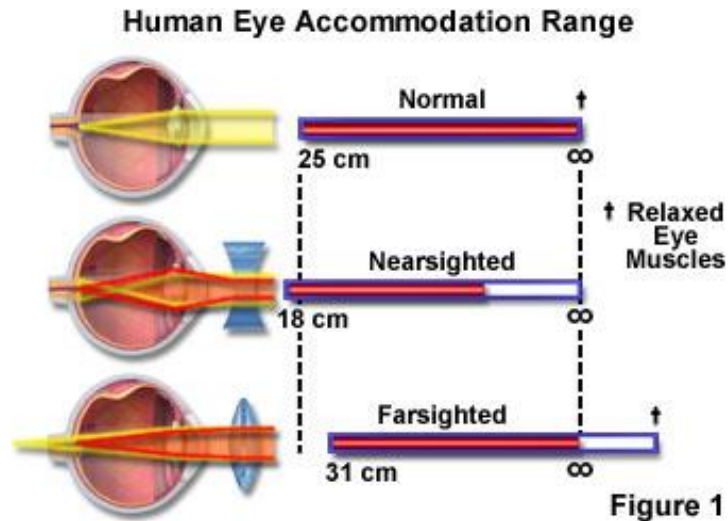
- The retina is a light-sensitive layer at the back of the eye. It has Photosensitive cells called [rods and cones](#) in the retina convert incident light energy into signals that are carried to the brain by the optic nerve.
- In the middle of the retina the [fovea](#). It is the center of the eye's sharpest vision and the location of most color perception
- The [Cornea](#) is tough, transparent, membrane which forms the front surface of the eye
- The [lens](#) focuses the image on the Retina
- The [Iris](#) القزحية controls the amount of lighting the eye through controlling the size of the pupil
- The [optic nerve](#) transmits visual information from the retina to the brain



- the 6 to 7 million cones can be divided into "red" cones (64%), "green" cones (32%), and "blue" cones (2%). They provide the eye's color sensitivity. The green and red cones are concentrated in the [fovea centralis](#). The "blue" cones have the highest sensitivity and are mostly found outside the fovea, leading to some distinctions in the eye's [blue perception](#).
- the cones are responsible for all high resolution vision.
- The [rods](#) are the most numerous of the [photoreceptors](#), some 120 million, and are more sensitive than the [cones](#). However, they are not sensitive to color. They are responsible for our dark-adapted. More than one thousand times as sensitive as the cones. the rod adaption process is much slower than that of the cones.
- While the visual acuity or visual resolution is much better with the cones, the rods are better motion sensors. Since the rods predominate in the peripheral vision, that peripheral vision is more light sensitive, enabling you to see dimmer objects in your peripheral vision.



Focusing problems



FACTORS IN VISUAL ACUITY

Object	The observer	The lighting conditions
Size	Condition of the eyes (both health and age)	Illumination level
Luminance (brightness)	Adaptation level	Disability glare
Contrast, including color contrast	Fatigue level	Discomfort glare
Exposure time—needed or given	Subjective impressions; psychological reactions	Luminance ratios
Type of object—required mental activity;		Brightness patterns
familiarity with the object (in reading, familiarity is so important as to become the primary factor)		
Degree of accuracy required		
Task—moving or stationary		

Cm	Inches													Distance Equivalents Decimal									
620	256	O	S	N	R	H							.06	20 333									
500	192	Z	C	D	V	O	N							.08	20 250								
400	160	C	K	V	R	N	H	D	O					.1	20 200								
310	128	D	H	Z	V	K	V	R	C	O	S	N	.12	20 167									
250	96	R	N	H	S	O				K	D	C	Z	V	.16	20 125							
200	80	V	R	N	H	Z					D	C	K	S	O	.2	20 100						
160	64	S	O	C	Z	N					H	R	V	D	K	.25	20 80						
125	48	N	H	R	O	C			C	V	H	R	N	V	Z	S	K	D	.33	20 60			
100	40	C	V	O	R	D			D	O	S	K	R			S	K	H	Z	.4	20 50		
80	32	H	E	V	E	O				H	E	D	O	V			R	K	N	E	.5	20 40	
60	24	K	E	R	N	E				K	R	E	N	E			D	H	E	V	E	.66	20 30
50	20																			.8	20 25		
40	16																			1.0	20 20		
30	13																			1.2	20 16.7		

TABLE 11.2 Typical Luminance Values^a

Object	Luminance	
	cd/m ²	Footlamberts
Black glove on a cloudy night	0.0003	0.0001
Wall brightness in a well-lighted office	100	30
This sheet of paper in an office	120	35
Green electroluminescent lamp	150	45
Asphalt paving—overcast day	1,300	380
North sky	3,500	1,000
Moon, candle flame	4,000–5,000	1,300
Fluorescent tube	6,000–8,000	2,200
Kerosene flame	8,500	2,500
Hazy sky or fog	15,000	4,400
Snow in sunlight	25,000	7,300
100-W inside frost incandescent lamp	50,000	14,600
Sun	2.3 E9	0.67 E9

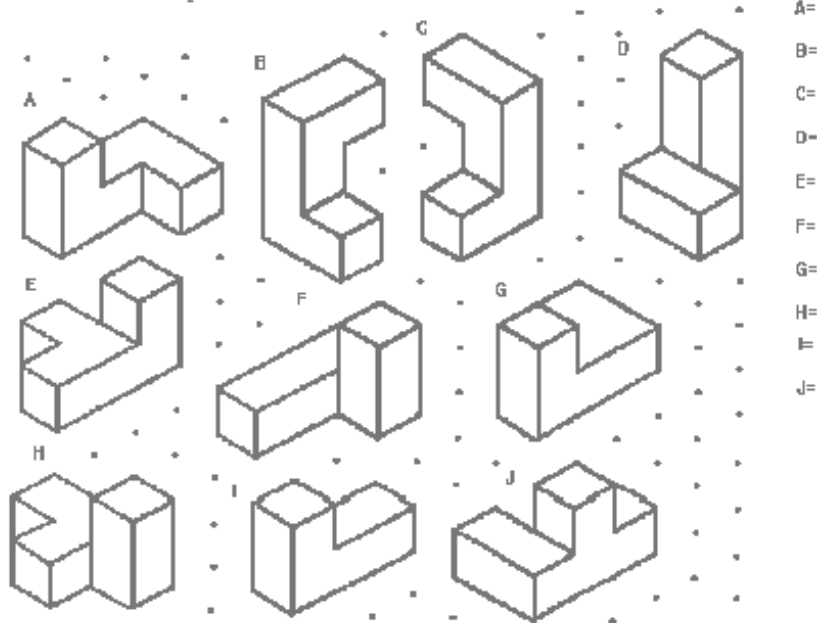
Eye can see light in a range 3 – 1000000 cd/m²

TABLE 11.3 Preferred and Permissible Luminances

Item	Luminance in cd/m^2
Recommended road luminance	1–2
Minimum discernible, chromatic	2–3
Clearly discernible human features	15–20
Preferred wall luminance	25–150
Preferred ceiling luminance	50–250
Preferred task luminance	100–500
Permissible luminaire luminance (depending on position in field of vision)	1000–7000



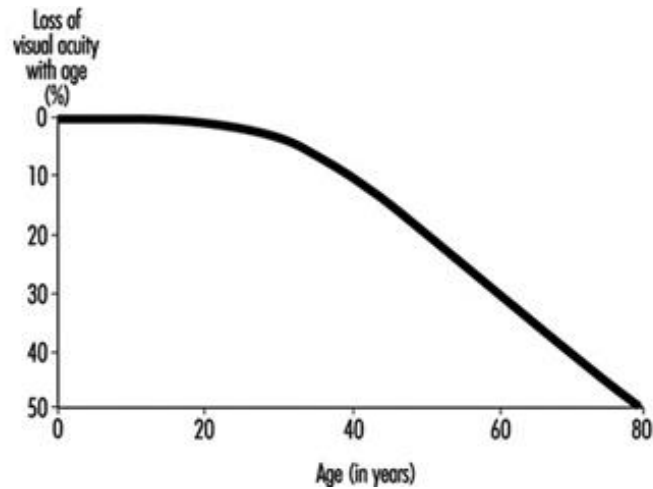
1. Shade in all right hand faces.
2. Match the solids in pairs.



I CAN READ IT ! CAN YOU ???

fi yuo cna raed tihs, yuo hvae a sgtrane mnid too. Cna yuo raed tihs? Olny smoe plepoe can. i cdnuolt blveiee taht I cluod aulacly uestnatnrd waht I was rdanieg. The phaonmneal pweor of the hmuan mnid, aoccdrnig to a rscheearch at Cmabrigde Uinervtisy, it dseno't mtaetr in waht oerdr the ltteres in a wrod are, the olny iproamtnt tihng is taht the frsit and lsat ltteer be in the rghit pclae. The rset can be a taotl mses and you can sitll raed it whotuit a pboerlm. Tihs is bcuseae the huamn mniddeos not raed ervey lteter by istlef, but the wrod as a

The observer



The lighting condition

Quantity of light

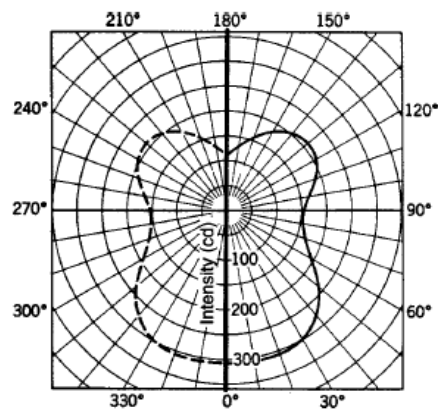


Fig. 11.15 Typical luminous intensity (cd) distribution curve for a general diffuse-type luminaire. Because the unit is symmetric about its vertical axis, only one curve need be shown. Furthermore, only the right side of this curve need be shown, due to symmetry.

Illumination level standards

- (IESNA: **Illuminating Engineering Society of North America**) recommendations were originally developed analytically by extrapolation from extensive laboratory tests

Reference: IESNA Lighting Handbook

- **CIBSE: Certified Institute of Building Services Engineers**
The British (and, to a large extent, the European) approach was to study specific tasks in actual and simulated field conditions
- **CIE (Commission Internationale de l'Eclairage)**
international commission for lighting

Illuminance categories

Category of Visual Task	Required E (lux) ^a	
	RF = 50%	RF = 10%
Casual	62–125	300–625
Ordinary	125–625	625–3,125
Moderate	625–1,250	3,125–6,250
Difficult	1,250–2,500	6,250–12,500
Severe	>2,500	>12,500

Category of Visual Task	Required Luminance (cd/m ²)
Causal	10–20
Ordinary	20–100
Moderate	100–200
Difficult	200–400
Severe	Above 400

$$L = \frac{E \times RF}{\pi}$$

and in I-P units,

$$fL = fc \times RF$$

Illuminance recommendation

TABLE 11.4 Typical Illuminance Recommendations, CIBSE (UK)

<i>Offices and Shops</i>		
	Standard Maintained Illuminance (lux)	Notes
OFFICES		
General offices	500	Local lighting may be appropriate
Computer workstations	300–500	See ref. 25
Conference rooms, executive offices	300–500	Dimming or switching to permit use
Computer and data preparation rooms	500	See ref. 25
Filing rooms	300	Vertical surfaces may be especially important
DRAWING OFFICES		
General	500	
Drawing boards	750	Local lighting may be appropriate
Computer-aided design and drafting	300–500	Special lighting is required; see ref. 25
Print rooms	300	

Source: Reproduced with permission from the CIBSE *Code for Interior Lighting* (1994).

Reference 25: CIBSE Lighting Guide LG3: Areas for Visual Display Terminals

Notes:

The information in the table will be influenced by reference to the "core recommendations" in Sections 4.3 to 4.5 of the Code.

Check that installations designed to meet the needs of visual display screen tasks also have the task-to-wall and task-to-ceiling ratios recommended in Section 4.4 of the Code.

Where air conditioning or mechanical ventilation is required, air-handling luminaires may be appropriate.

Energy recommendations recommended minimum levels

CIBSE Recommended Illumination Levels			
Area	Recommended Lighting Level	Area	Recommended Lighting Level
Offices			
General	500 Lux	Drawing Office	500 Lux
Computer Work Stations	300-500 Lux	Drawing Boards	750 Lux
Filing rooms	300 Lux	CAD Design Areas	300-500 Lux
Print Rooms	300 Lux		
Retailing			
Small Retail Outlets	500 Lux	DIY Superstore	1000 Lux
Supermarkets	750 Lux	Garden Centres	500 Lux
Hypermarkets	1000 Lux	Showrooms	500-750 Lux
Engineering			
Tool Shops	300-750 Lux	Heavy Machine Assembly	300 Lux
Arc Welding	300 Lux	Inspection and Testing	500- 2000 Lux
Spot Welding	500- 1000 Lux		
Banks & Building Societies			
Counter & Offices	500 Lux	Public Areas	300 Lux
Staff Rooms			

TABLE 11.5 Examples of Activities/Interiors Appropriate for Each Maintained Illuminance

Standard Maintained Illuminance (lux)	Characteristics of Activity/Interior	Representative Activities/Interiors
50	Interiors used rarely with visual tasks confined to movement and casual seeing without perception of detail	Cable tunnels, indoor storage tanks, walkways
100	Interiors used occasionally with visual tasks confined to movement and casual seeing calling for only limited perception of detail	Corridors, changing rooms, bulk stores, auditoria
150	Interiors used occasionally or with visual tasks not requiring perception of detail but involving some risk to people, plant, or product	Loading bays, medical stores, plant rooms
200	Interiors occupied for long periods or for visual tasks requiring some perception of detail	Foyers and entrances, monitoring automatic processes, casting concrete, turbine halls, dining rooms
300 ^a	Interiors occupied for long periods, or when visual tasks are moderately easy (i.e., large details >10-min arc) and/or high contrast	Libraries, sports and assembly halls, teaching spaces, lecture theaters, packing
500 ^a	Visual tasks moderately difficult (i.e., details to be seen are of moderate size [5–10 min arc] and may be of low contrast); also, color judgment may be required	General offices, engine assembly, painting and spraying, kitchens, laboratories, retail shops
750 ^a	Visual tasks difficult (i.e., details to be seen are small [3–5 min arc] and of low contrast); also, good color judgments or the creation of a well-lit, inviting interior may be required	Drawing offices, ceramic decoration, meat inspection, chain stores
1000 ^a	Visual tasks very difficult (i.e., details to be seen are very small [2–3 min arc] and can be of very low contrast); also, accurate color judgments or the creation of a well-lit, inviting interior may be required	General inspection, electronic assembly, gauge and tool rooms, retouching paintwork, cabinet making, supermarkets
1500 ^a	Visual tasks extremely difficult (i.e., details to be seen are extremely small [1–2 min arc] and of low contrast); optical aids and local lighting may be of advantage	Fine work and inspection, hand tailoring, precision assembly
2000 ^a	Visual tasks exceptionally difficult (i.e., details to be seen are exceptionally small <1 min arc) with very low contrast; optical aids and local lighting will be of advantage	Assembly of minute mechanisms, finished fabric inspection

TABLE 11.6 Design Maintained Illuminance Flowchart^a

Standard Maintained Illuminance (lux) ^b	Task Size and Contrast ^c		Task Duration ^d		Error Risk ^e		Design Maintained Illuminance (lux) ^f
	Unusually Difficult to See?	Unusually Easy to See?	Unusually Long Time?	Unusually Short Time?	Serious for People, Plant, or Product?		
200	Yes → 200	200 → Yes	Yes → 200	200 → Yes	Yes → 200	Yes → 200	200
	250 → Yes	250 → Yes	250 → Yes	250 → Yes	250 → Yes	250 → Yes	250
300	Yes → 300	Yes → 300	Yes → 300	Yes → 300	Yes → 300	Yes → 300	300
	400 → Yes	400 → Yes	400 → Yes	400 → Yes	400 → Yes	400 → Yes	400
500	Yes → 500	Yes → 500	Yes → 500	Yes → 500	Yes → 500	Yes → 500	500
	600 → Yes	600 → Yes	600 → Yes	600 → Yes	600 → Yes	600 → Yes	600
750	Yes → 750	Yes → 750	Yes → 750	Yes → 750	Yes → 750	Yes → 750	750
	900 → Yes	900 → Yes	900 → Yes	900 → Yes	900 → Yes	900 → Yes	900
	1000 → Yes	1000 → Yes	1000 → Yes	1000 → Yes	1000 → Yes	1000 → Yes	1000
			1300 → Yes	1300 → Yes	1300 → Yes	1300 → Yes	1300
			1500 → Yes	1500 → Yes	1500 → Yes	1500 → Yes	1500

Source: Reproduced with permission from the CIBSE Code for Interior Lighting (1994).

^aTo use the chart, follow the horizontal path from the "standard" maintained illuminance in the schedule until the answer to a question is "yes." If the "yes" is strong, follow the solid arrow; if moderate, follow the dashed arrow.

^bThe flowchart should be used for all standard maintained illuminance recommendations from 200 to 750 lux for general activities and interiors in the lighting schedule. For recommendations of 150 lux or less, the modifying factors are not relevant (see Table 11.5). Where a standard maintained illuminance of more than 750 lux is recommended, this always applies to a stated task for specific industries or activities where the modifying factors have usually been taken into account.

^cThe standard maintained illuminance given in the schedule assumes that the task is representative of its type. If the task is much more visually difficult than usual (e.g., smaller size, lower contrast), then an increase in the maintained illuminance is appropriate. Reduced contrast may arise from the use of safety lenses or safety screens because they reduce the transmission of light. Increase illuminance to take account of the age or eyesight of the operator. Conversely, if the task detail is such that the task is easier to see than usual (e.g., larger size, higher contrast), a reduction in maintained illuminance can be made.

^dThe standard maintained illuminance given in the schedule assumes that the task is to be undertaken over a conventional working period.

TABLE 11.7 Determination of Illuminance Categories*

Orientation and simple visual tasks. Visual performance is largely unimportant. These tasks are found in public spaces where reading and visual inspection are only occasionally performed. Higher levels are recommended for tasks where visual performance is occasionally important.		
A	Public spaces	30 lx (3 fc)
B	Simple orientation for short visits	50 lx (5 fc)
C	Working spaces where simple visual tasks are performed	100 lx (10 fc)
Common visual tasks. Visual performance is important. These tasks are found in commercial, industrial, and residential applications. Recommended illuminance levels differ because of characteristics of the visual task being illuminated. Higher levels are recommended for visual tasks with critical elements of low contrast or small size.		
D	Performance of visual tasks of high contrast and large size	300 lx (30 fc)
E	Performance of visual tasks of high contrast and small size, or visual tasks of low contrast and large size	500 lx (50 fc)
F	Performance of visual tasks of low contrast and small size	1000 lx (100 fc)
Special visual tasks. Visual performance is of critical importance. These tasks are very specialized, including those with very small or very low contrast critical elements. Recommended illuminance levels should be achieved with supplementary task lighting. Higher recommended levels are often achieved with supplementary task lighting. Higher recommended levels are often achieved by moving the light source closer to the task.		
G	Performance of visual tasks near threshold	3000 to 10,000 lx (300 to 1000 fc)

*Expected accuracy in illuminance calculations should be checked with formulas in the *IESNA Lighting Handbook*. To account for both uncertainty in photometric measurements and uncertainty in space reflections, measured illuminances should be within 10% of the recommended value. It should be noted, however, that the final illuminance may deviate from the recommended values due to the other lighting design criteria.

Source: Reproduced with permission from the *IESNA Lighting Handbook*, 9th ed. (2000).

TABLE 11.8 Suggested Adjustments^a to General Lighting Illuminance Values, for Illuminance Categories A, B, and C^b

Average Age of Occupants	Average Room Surface Reflectance (%) ^c	Illuminance (lux)		
		Categories		
		A	B	C
Under 40	Over 70	30	50	100
	30–70	40	75	150
	Under 30	40	75	150
40–50	Over 70	40	75	150
	30–70	40	75	150
	Under 30	40	75	150
Over 55	Over 70	40	75	150
	30–70	40	75	150
	Under 30	50	100	200

^aThe values in the first row represent the base recommendations from Table 11.7; values in other rows are suggested illuminance values for various combinations of occupant age and surface reflectance.

^bBased on IESNA recommendations—but adapted to illuminance recommendations in the *IESNA Lighting Handbook*, 9th ed.

^cAverage weighted surface reflectances, including wall, floor, and ceiling reflectances, if they encompass a large portion of the task area or visual surround. For instance, in an elevator lobby, where the ceiling height is 25 ft (7.6 m), neither the task nor the visual surround encompasses the ceiling, so only the floor and wall reflectances would be considered.

TABLE 11.9 Suggested Adjustments^a to Task Lighting Illuminance Values for Illuminance Categories D through F^b

ILLUMINANCE ON TASK (LUX)					
Average of Workers' Ages	Demand for Speed and/or Accuracy ^{1, c}	Task Background ² Reflectance (%)	Illuminance Categories		
			D	E	F
Under 40	NI	Over 70	300	500	1000
		30–70	300	500	1000
		Under 30	400	750	1500
	I	Over 70	300	500	1000
		30–70	400	750	1500
		Under 30	400	750	1500
	C	Over 70	400	750	1500
		30–70	400	750	1500
		Under 30	400	750	1500
	NI	Over 70	300	500	1000
		30–70	400	750	1500
		Under 30	400	750	1500
40–55	NI	Over 70	300	500	1000
		30–70	400	750	1500
		Under 30	400	750	1500
	I	Over 70	400	750	1500
		30–70	400	750	1500
		Under 30	400	750	1500
	C	Over 70	400	750	1500
		30–70	400	750	1500
		Under 30	600	1000	2000
	NI	Over 70	400	750	1500
		30–70	400	750	1500
		Under 30	400	750	1500
Over 55	NI	Over 70	400	750	1500
		30–70	400	750	1500
		Under 30	400	750	1500
	I	Over 70	400	750	1500
		30–70	400	750	1500
		Under 30	600	1000	2000
	C	Over 70	400	750	1500
		30–70	600	1000	2000
		Under 30	600	1000	2000

Notes

1. In determining whether speed and/or accuracy is not important, important, or critical, the following questions need to be answered: What are the time limitations? How important is it to perform the task rapidly? Will errors produce an unsafe condition or product? Will errors reduce productivity and be costly? For example, in reading for leisure there are no time limitations, and it is not important to read rapidly. Errors will not be costly and will not be related to safety, thus, speed and/or accuracy is not important. If, however, prescription notes are to be read by a pharmacist, accuracy is critical because errors could produce an unsafe condition, and time is important for customer relations.

2. The task background is that portion of the task upon which the meaningful visual display is exhibited. For example, on this page the meaningful visual display includes each letter, which combines with other letters to form words and phrases. The display medium, or task background, is the paper, which has a reflectance of approximately 85%.

^aThe values in the first row represent the base recommendations from Table 11.7; values in other rows are suggested illuminance values for various combinations of occupant age, task accuracy/speed, and task background reflectance.

^bBased on data from the IESNA Handbook, 8th ed. (1993)—but adapted to illuminance recommendations in the IESNA Lighting Handbook, 9th ed. Category G illuminance values are too broad to permit generalizations.

^cNI = not important; I = important; C = critical.

Quality of lighting

Excessive luminance (Glare) When the glare is caused by light sources in the field of vision, it is known as **direct glare**. When the glare is caused by reflection of a light source in a viewed surface, it is known as **reflected glare or veiling reflection**

1. The adaptation level is continuously varying as the eye is drawn to the glare source and away again
2. The eye is drawn simultaneously in two directions: involuntarily to the source of high luminance and volitionally to the object we are looking at. The resultant tension causes considerable visual discomfort
3. The eye adapts to a higher luminance level, thus effectively reducing the subjective brightness of the task—or, put more simply, making it harder to see what we are looking at

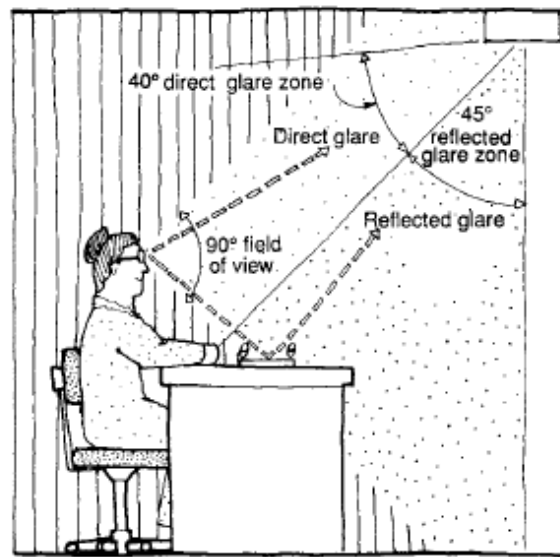


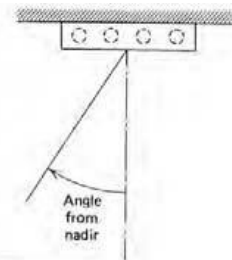
Fig. 11.23 Glare zones. Direct glare presupposes a head-up position, whereas reflected glare assumes eyes down at a reading angle.

**4-40-W Lamps
Prismatic Lens Diffuser**

Average Luminance Data cd/m²

Vertical Angles	Across Axes	Along Axes
60°	2000	1750
65°	1060	1075
70°	500	560
75°	410	380
80°	480	343
85°	560	420

Reflectances:
Wall 50%
Ceiling cavity 80%
Floor cavity 20%
Work plane illumination; 1000 lux



IES Visual Comfort Probability Data

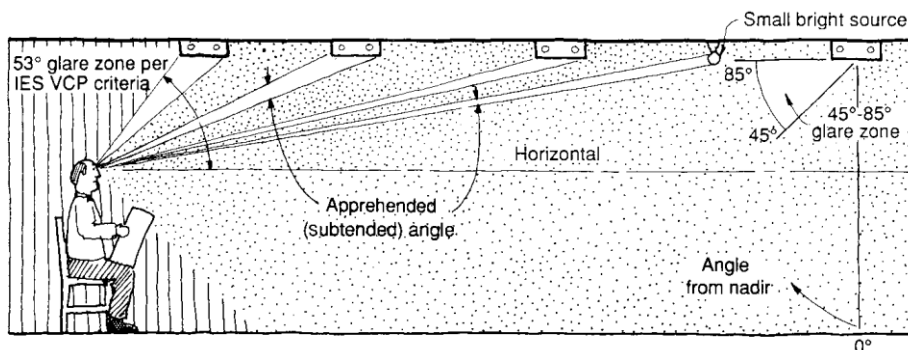
Room Size		Luminaires Lengthwise			Luminaires Crosswise		
W (ft)	L (ft)	Ceiling Height (in ft)					
		8.5	10.0	13.0	8.5	10.0	13.0
20 ×	20	80	77	76	79	75	72
	30	80	78	76	79	76	73
	40	82	79	77	79	77	74
	60	80	80	78	79	77	75
30 ×	20	84	80	77	82	78	74
	30	83	80	77	81	79	74
	40	82	80	78	81	79	75
	60	82	80	78	80	79	75
	80	82	80	78	80	78	76

Glare and luminance

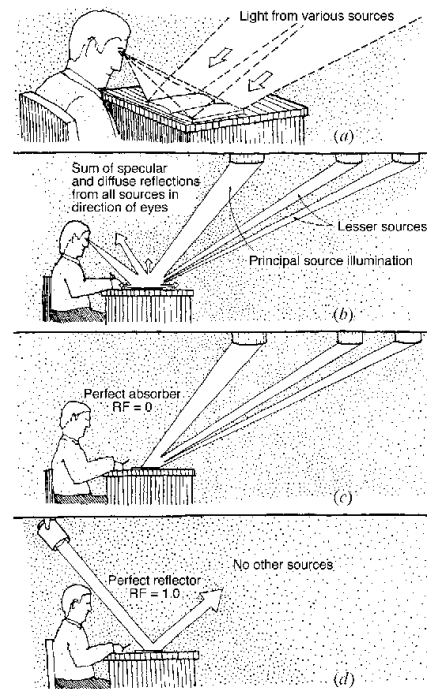
- The luminance of large sources should not exceed 2500 cd/m² (blue sky) and that of small sources should not exceed 7500 cd/m² (fluorescent lamp).

Angle Above Nadir (degrees)	Maximum Luminance (cd/m ²)
45	7710
55	5500
65	3860
75	2570
85	1695

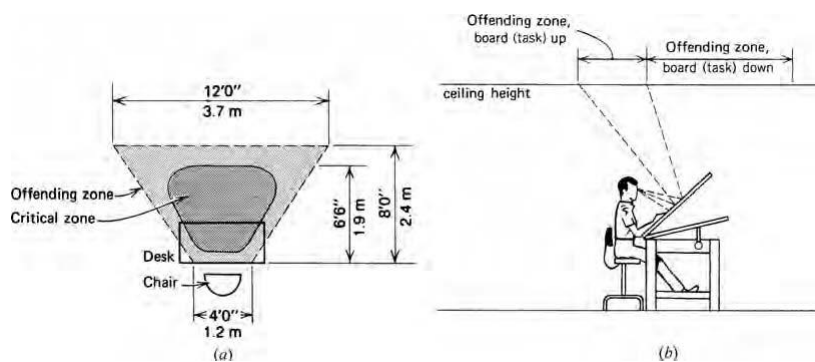
Control of direct glare

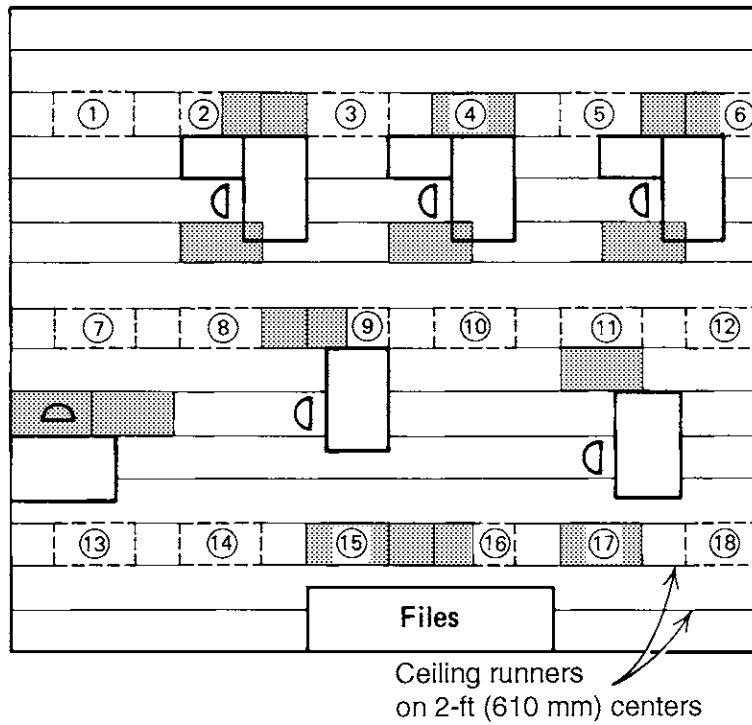


Control of reflected glare



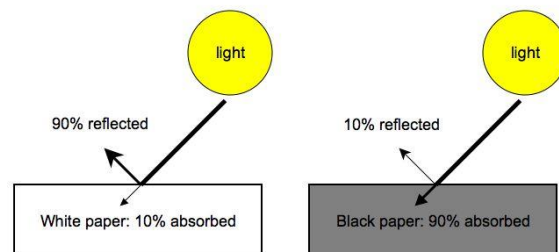
1. Physical Arrangement of System Elements





2. Control of Area Brightness and Eye Adaptation Level

Surface reflectance



3. Control of Source Characteristics

- Dimming or switching lamps
- Using luminaires with lower overall luminance
- Using the luminaire as a primary source to illuminate a large, low-brightness secondary source
- Reduce the luminaire luminance only at the offending angles

4. Changing the Task Quality

reducing the task specularity is at least as effective means of reducing veiling reflections as changing the lighting system characteristics, if not more

Location	Illuminance (lux or lm/m^2)	Limiting Glare Index
Entrance hall	150	22
Stairs	150	22
Corridors	100	22
Outdoor entrances	30	22
Casual assembly work	200	25
Rough/heavy work 300		28
Medium assembly work	500	25
Fine assembly work	1000	22
Precision work	1500	16
General office work	500	19
Computer room	750	16
Drawing office	750	16
Filing room	300	22
Shop counter	500	22
Supermarket	500	22
Classroom	300	16
Laboratory	500	16
Public house bar	150	22
Restaurant	100	22
Kitchen	500	22
Dwellings		
Living room	50	N/A
Reading room	150	N/A
Study 300		N/A
Kitchen	300	N/A
Bedroom	50	N/A
Hall/landing	150	N/A
Library		
Reading area	200	19
Tables	600	16
Counter	600	16

luminance ratios

visual performance increases with contrast—that is, with the difference in luminance between the object being viewed and its immediate surroundings. However, the difference between the average luminance of the visual field (task) and the remainder of the field of vision should be low to avoid the discomfort of large. Restated, **contrast is desirable in the object of view but undesirable in the wider surrounding field of view**

TABLE 11.11 Recommended Maximum Luminance Ratios^a

Note: To achieve a comfortable brightness balance, it is desirable to limit luminance ratios between areas of appreciable size as seen from normal viewing positions as follows:	
1 to one-third	Between task and adjacent surroundings
1 to one-tenth	Between task and more remote darker surfaces
1 to 10	Between task and more remote lighter surfaces
20 to 1	Between luminaires (or fenestration) and surfaces adjacent to them
40 to 1	Anywhere within the normal field of view

^aThese ratios are recommended as maximums; reductions are generally beneficial.