ART 2640, Building Systems of Interior Environments

Fall Semester 2020

Tuesdays & Thursdays 10:30-11:50

Online

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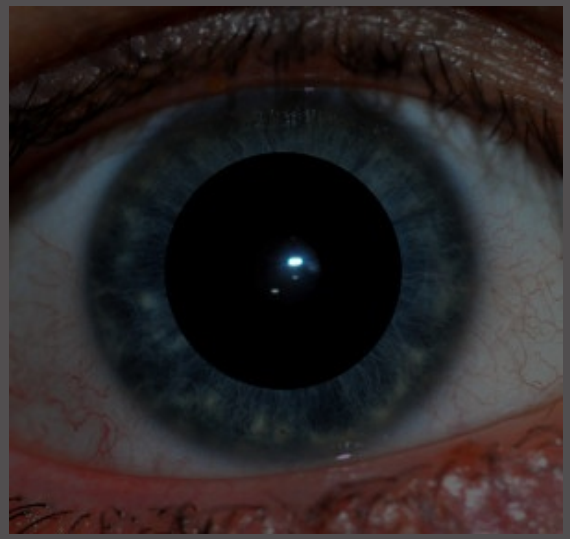
Lighting:
The Power and Purpose of Light

Lighting:
The Power and Purpose of Light

- Why we study light.
  - Vision – we need visible light in order to see anything!
  - The alteration of appearance and emotional effects
- Light Intensity
  - Bright vs. Dark
  - Warm vs. Cool
- Light Texture
  - Directional - ability to be directed
  - Diffuse – overlapping light filling in shadows
- How we use light
  - Mood – create or alter
  - Instruction – Light informing information
- Phototropism
  - Attraction to light

The Goal of Lighting Design:
More Impact with Less light

- Adaptation: adapting (changing) to bright/dark situations

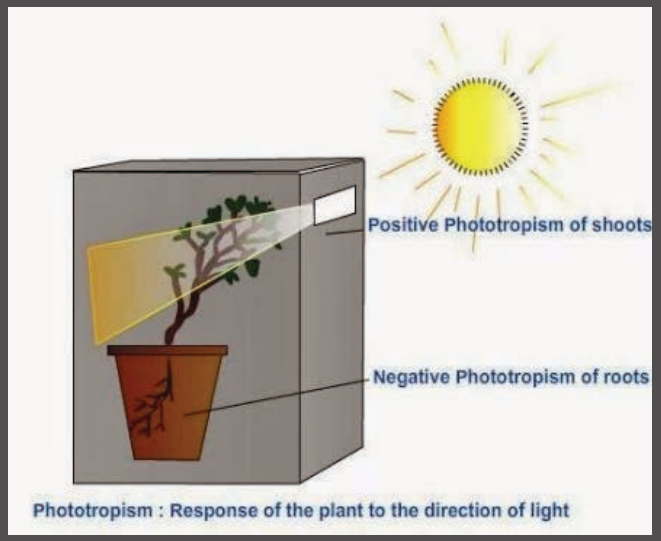


Lighting:
More Impact with Less light

- Brightness: contrast between surfaces and their surroundings

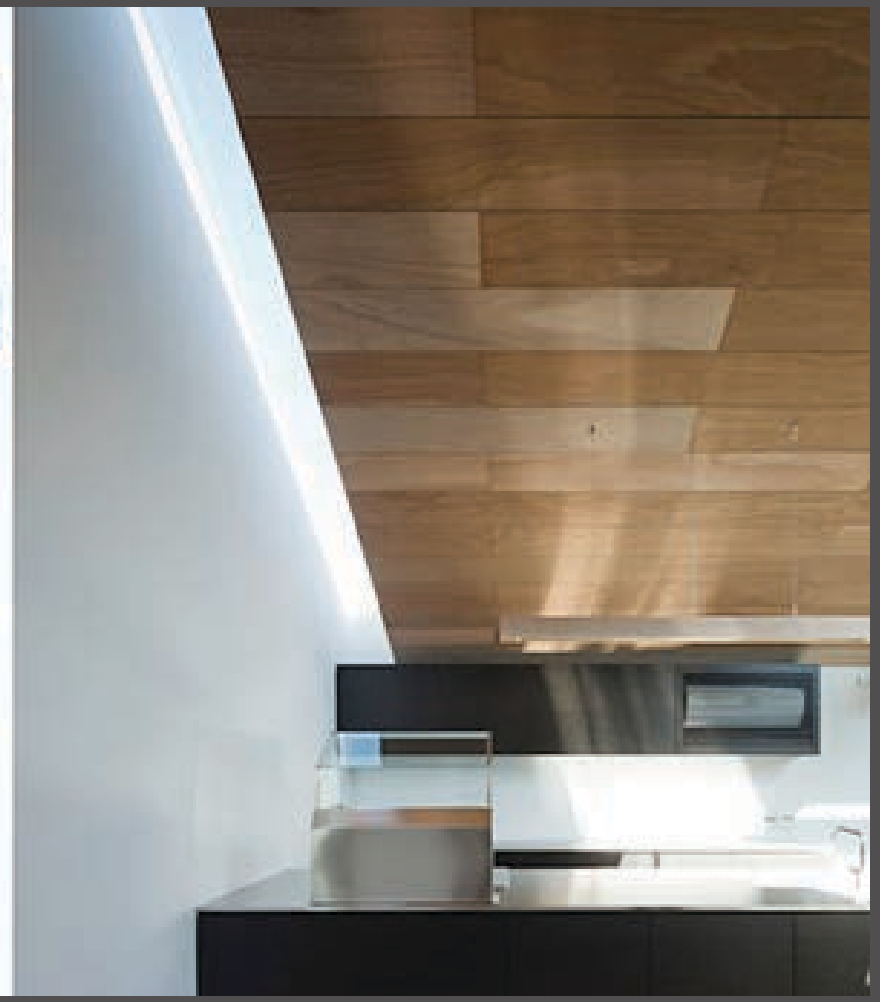
Lighting:
More Impact with Less light

- Phototropism: attraction to lighted surfaces and objects



Using light to draw us near

Using light to get our attention



Rather than adding on and further ‘thickening’ the existing house, the new addition is ‘grafted’ onto the existing entry where the levels of the house are already split. An extended stair serves as the stitches that bind the addition to the original house creating a new Master Bedroom suite and home offices for both work-at-home parents. Like a plant, the addition ‘grows’ towards light and views.
BSC Architects 2008

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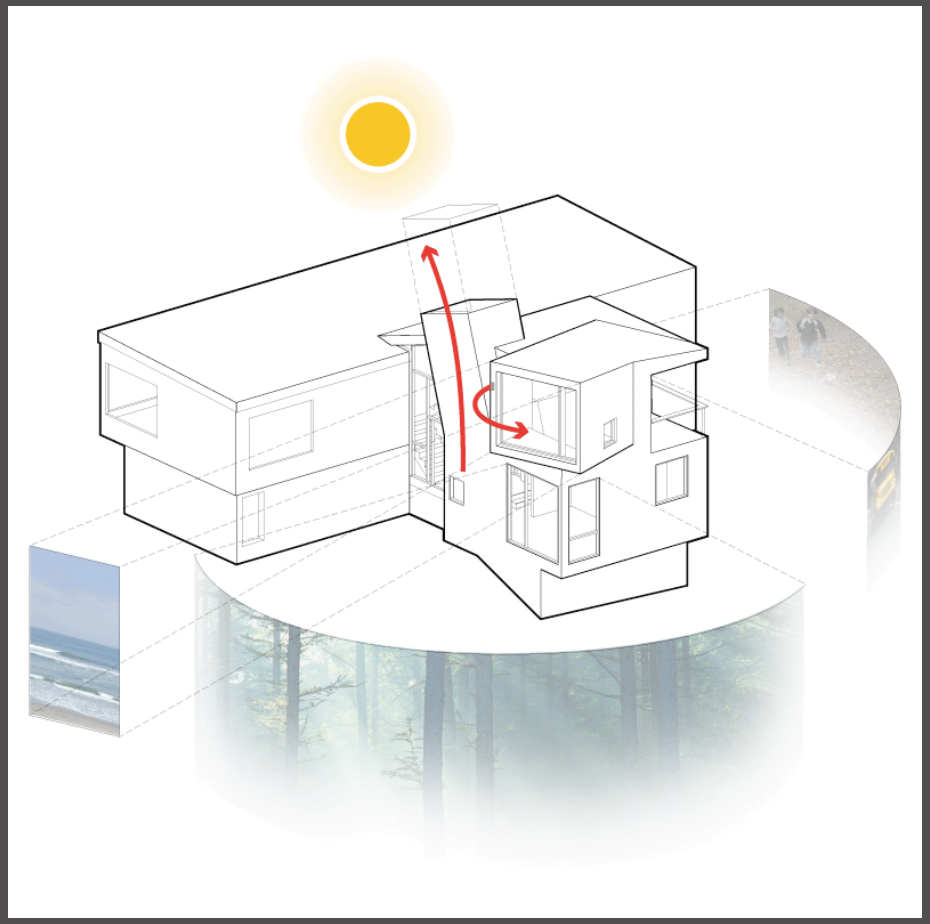
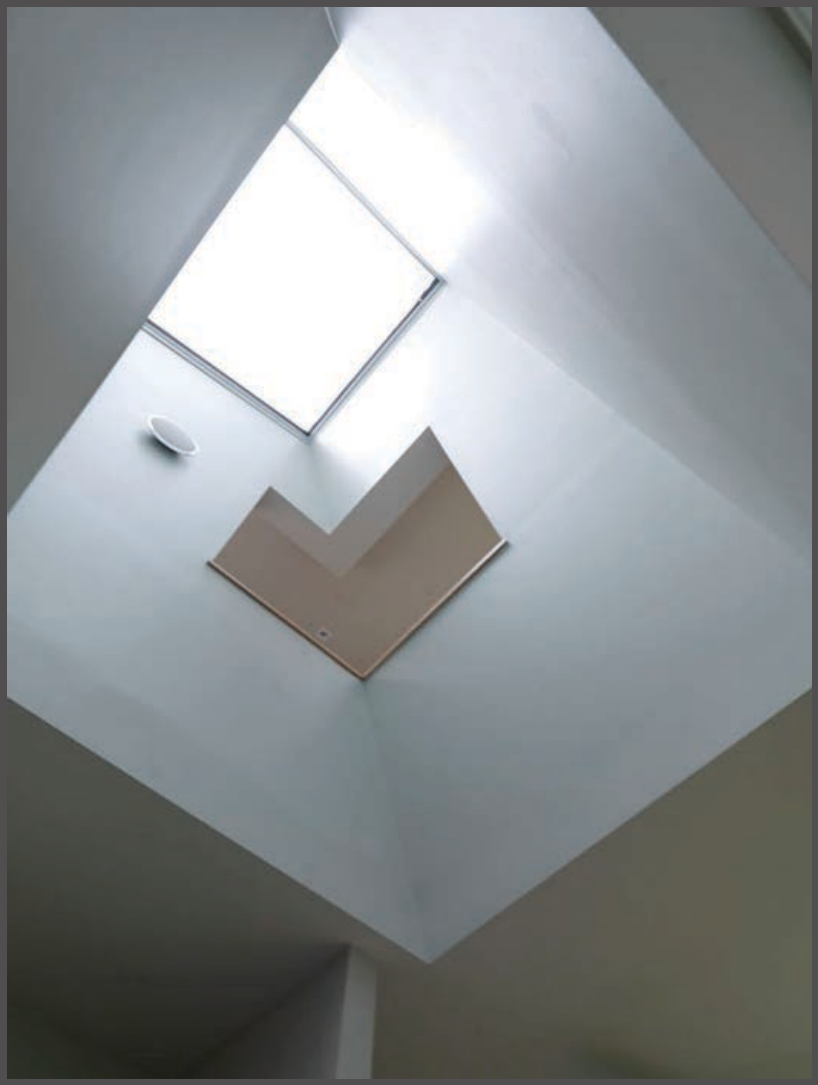
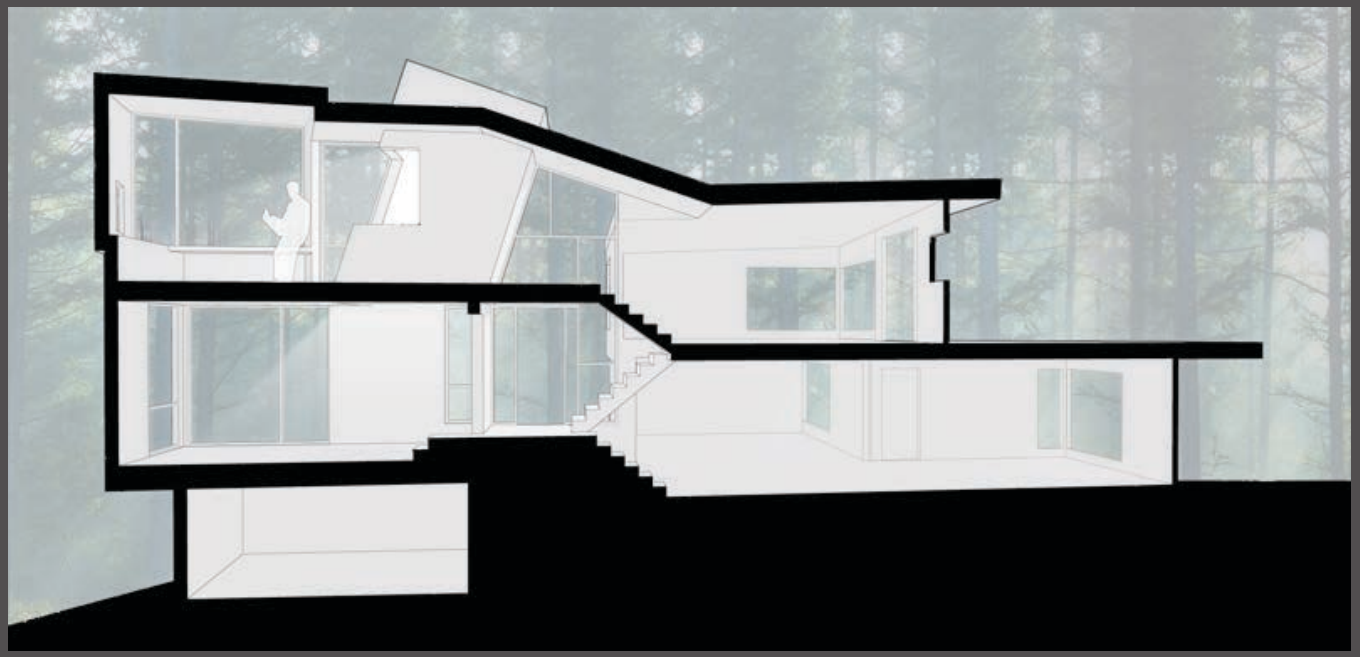
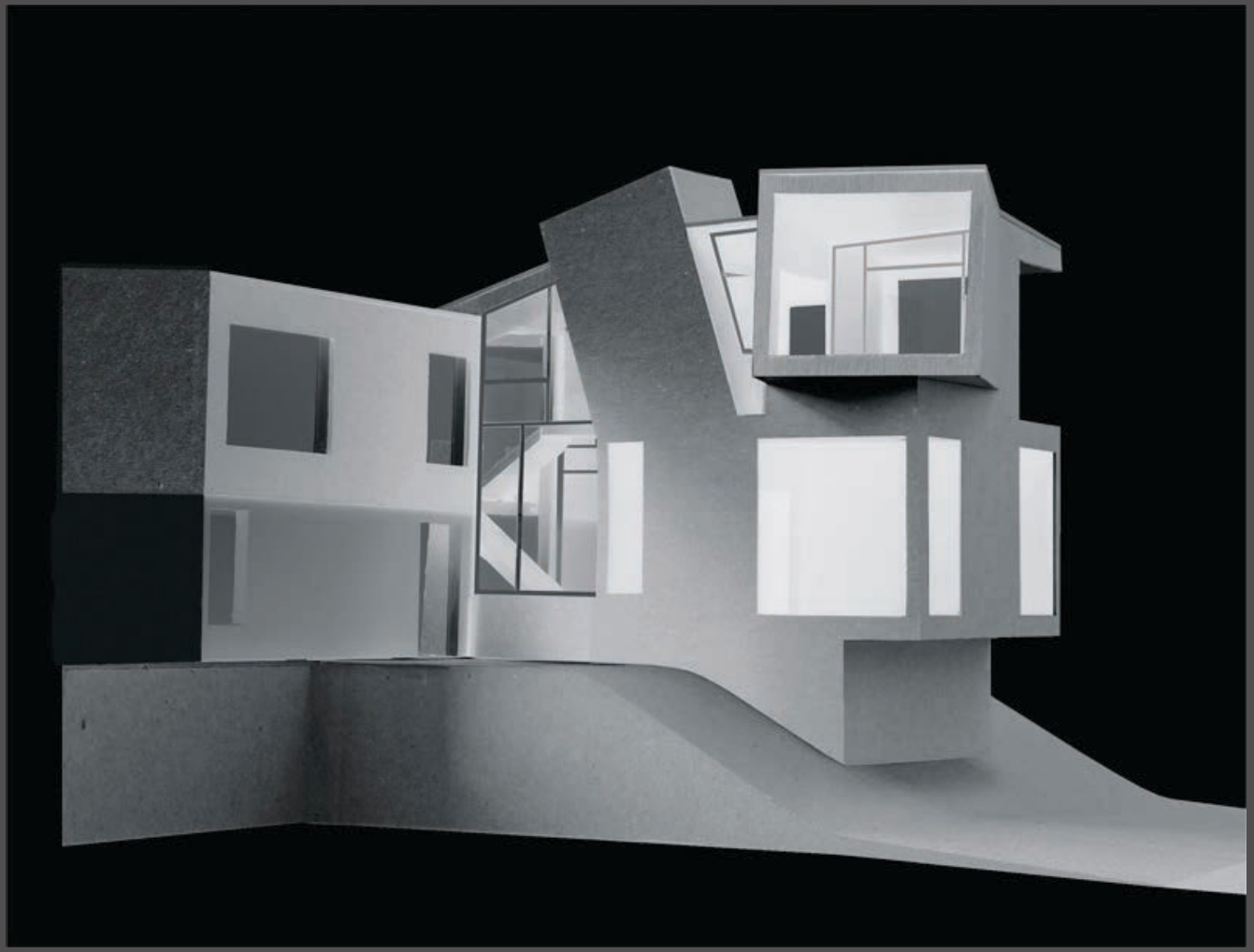


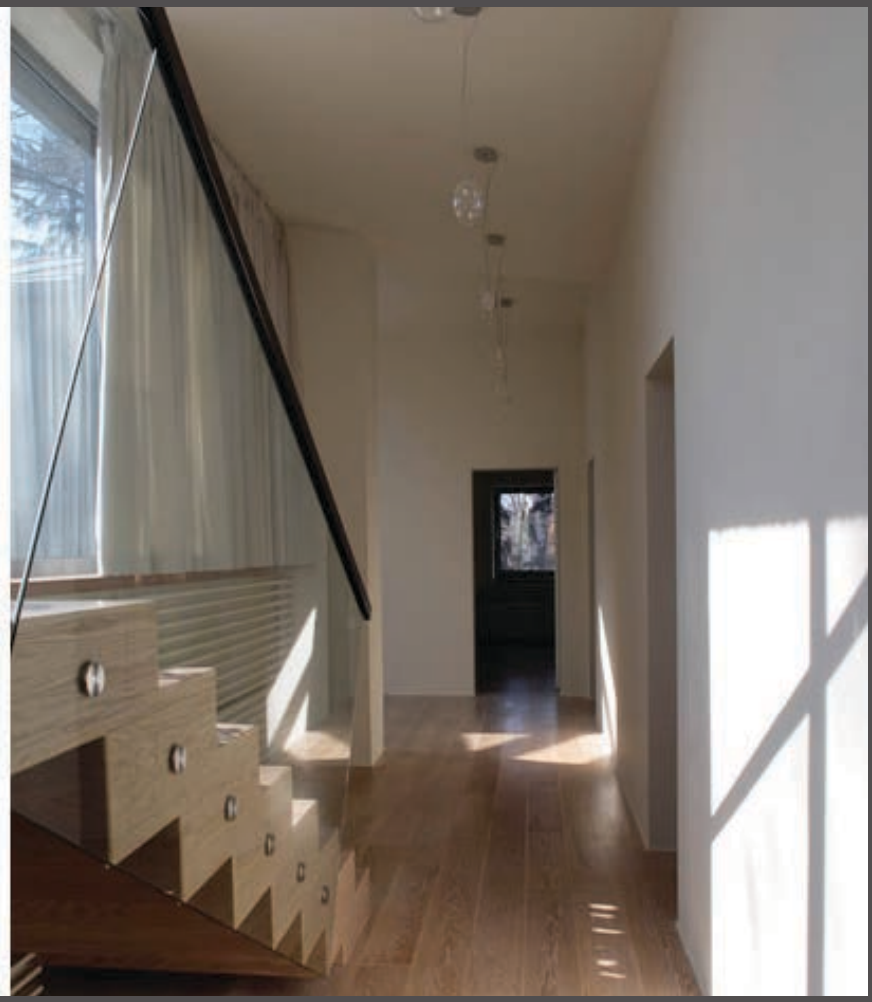






A House Shaped By Nature:
Daylighting & Electric Lighting

Intentional use of daylight to enrich space and form



Lighting:
More Impact with Less light

- Horizontal Vision: tendency to look around us rather than up or down.

Lighting:
Adding Light in Layers

- Layer 1: Lighting to choreograph an experience
  - Create goals, paths and destinations to encourage flow and movement
- Layer 2: Lighting to define mood and ambience
  - Intensity, color and texture to elicit emotion and encourage use in space
- Layer 3: Lighting to accent objects
  - Draws visual interest and encourage interaction by making things stand out
- Layer 4: Lighting to reveal architecture and space (form)
  - Apply light to features and details to enhance spatial effects and reveal the mechanics of structure and form
- Layer 5: Lighting for tasks
  - Light applied to task areas to accommodate the basic functions of space

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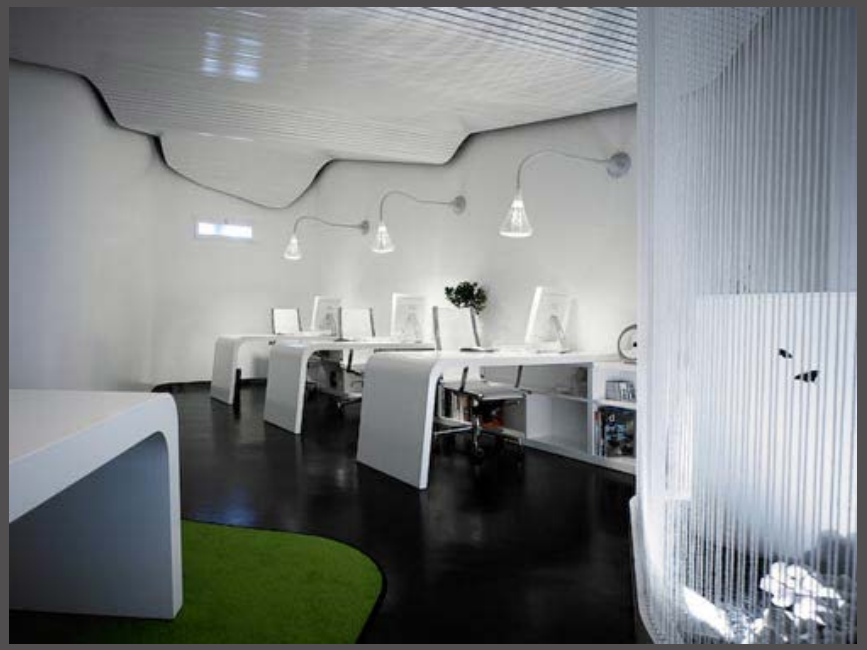

LIGHT AND PERCEPTION

Classification of Lighting Effects

Receiving and Analyzing of Light

The Eye and Vision

Quality of Light

Quantity of Light

CLASSIFICATION OF LIGHT

Ambient Light - General Overall Lighting. (For general tasks such as navigating space.) The light that strikes all of the surfaces.

Task Light - Lighting for specific tasks. (Specific tasks that require accuracy and or efficiency.)

Accent Light - Lighting provided for aesthetic or visual interest. (Research indicating that it is an important aspect of overall environmental experience.)

These categories are NOT absolute: we use these terms to generally describe what the light is doing in a space.

CLASSIFICATION OF LIGHT

Ambient Light
Task Light
Accent Light

The design of a single space may include ambient, task and accent lighting. A single light source may provide one or all three classifications.

When analyzing light classifications study where the light is falling then track it back to the source.

AMBIENT LIGHT

AMBIENT LIGHT

TASK LIGHT

TASK LIGHT

ACCENT LIGHT

project **University Mall**
Tampa, FL
lighting **Gerry Zekowski**
architect **Anthony Beluschi Architects, Ltd.**
interior **SDI/HTI**
photographer **George Cott**

The geographic and visual centerpiece of University Mall is its center court, which features an "undersea" tableau of fish, underwater sunlight, and blue-painted and yellow-neon waves. Schools of foam-board fish dangle from the aircraft cable. Curved ceiling forms house light fixtures reminiscent of sparkling sunlight seen from beneath the water's surface. At ground level are wave-shaped fountains with planters and built-in seating.

171

43

ACCENT LIGHT

In this room, the lighting provided is:
?
(ambient, accent, task?)

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?
(ambient, accent, task?)

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?
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?
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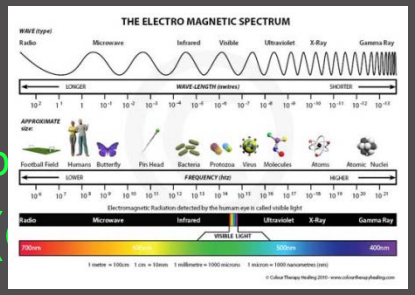
Lighting:
Physical Basics of Light

- Light as Radiation
  - Radiation is power (energy) – electromagnetic energy spectrum
  - Travels at the speed of "light"
    - about 186,000 miles per second
  - Various forms exist because of the different rates of vib
    - Wavelengths – measured in nanometers (meter)
      - Visible light – 380 – 770 Nanometers
        - Color is a breakdown of visible light (rainbow)



Lighting:
Physical Basics of Light

- Evolution of Color Vision
  - Radiation can be reflected off a surface
  - Radiation can be absorbed by the surface
  - Radiation can transmit or pass through the surface.

- Basic Lighting Interaction Terminology
  - Illuminance – quantity (amount) of light falling onto an object.
  - Exitance – total quantity (amount) of light leaving a surface.
  - Luminance – the phenomena of light leaving a surface at a specific direction.

Lighting:
Physiology of Vision

- Adaptation
  - The mechanics of controlling the amount of light that enters the eye and is translated by the brain
- Accommodation
  - The ability of the eye to focus on objects at different distances.
- Structure of the eye
  - Periphery – rods – detect low levels of light
  - Macula – rods and cones – mixture of both
  - Fovea – cones – translate details and color
    - Rods – sensitive to subtle light changes and motion – scotopic
    - Cones – responsible for our color vision - photopic

RECEIVING AND ANALYZING LIGHT

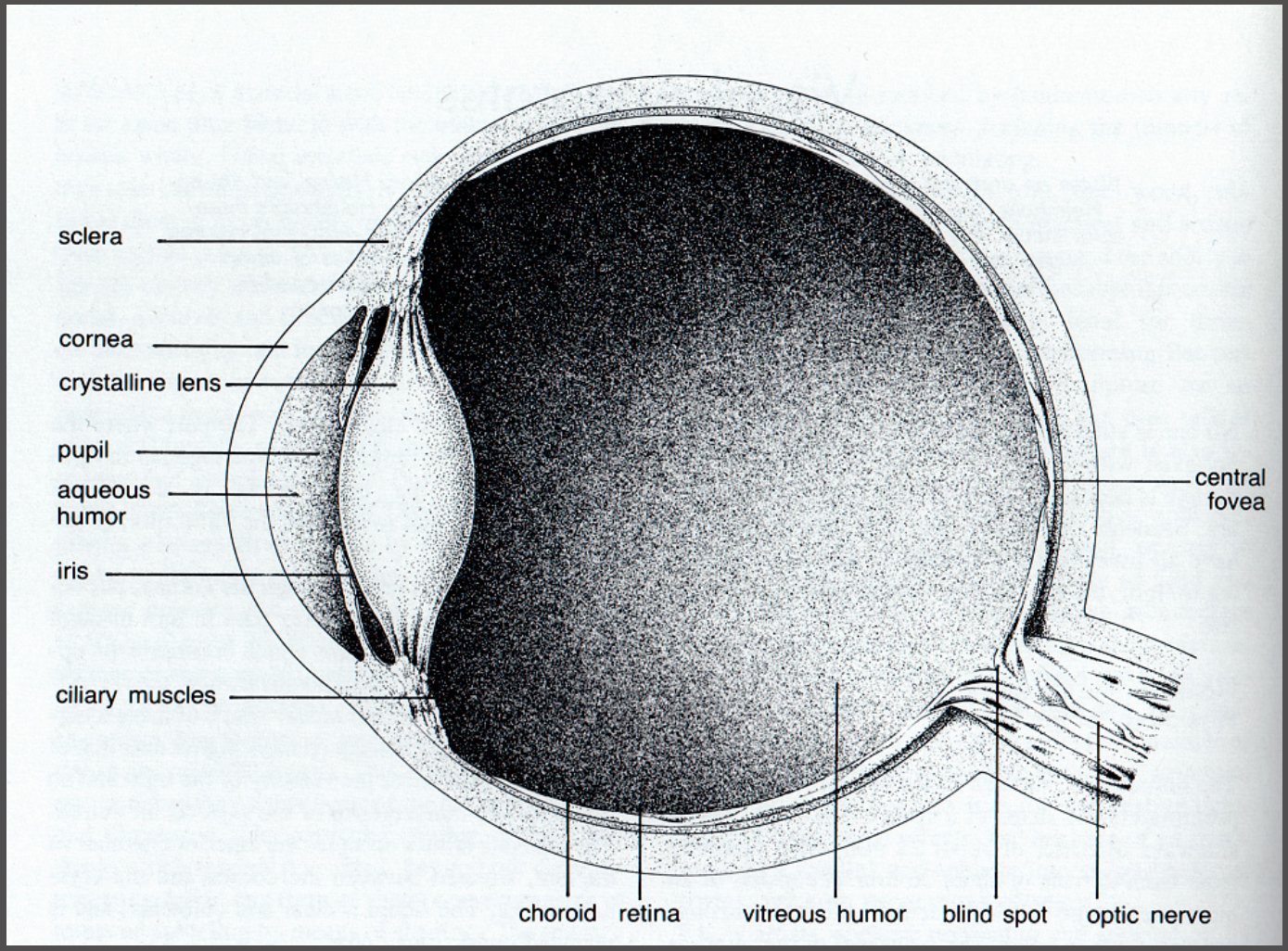
- Generators
- Modifiers and Retransmitters
- Receivers and Encoders
- Decoders and Interpreter

RECEIVING AND ANALYZING LIGHT

Generators | Modifiers and Retransmitters | Receivers and Encoders | Decoders and Interpreter

What part of Receiving and Analyzing Light Does the Designer Control?

THE EYE AND VISION -FUNCTION OF THE EYE

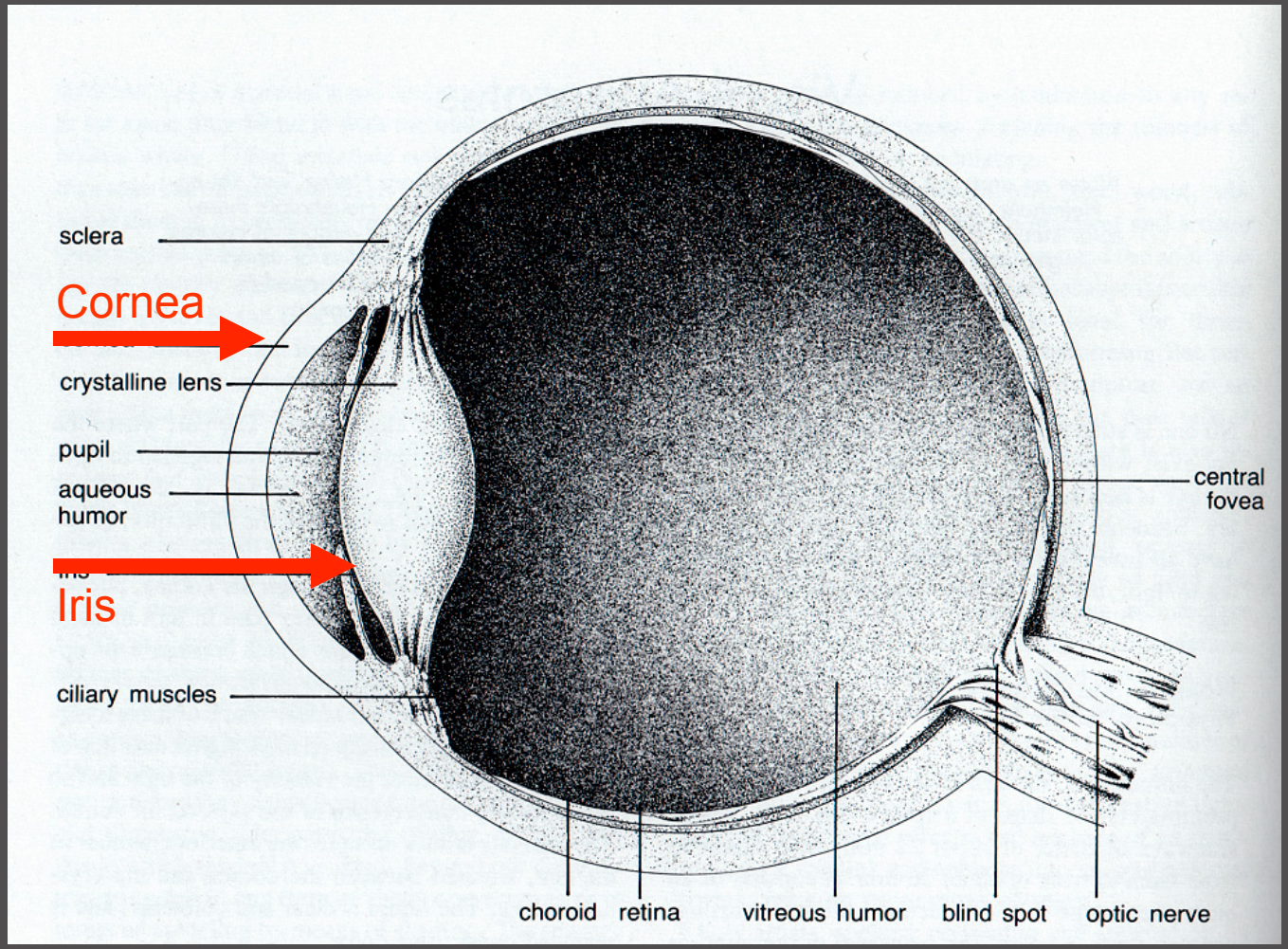


THE EYE AND VISION -FUNCTION OF THE EYE

The eye contains 70% of the bodies senses receivers.

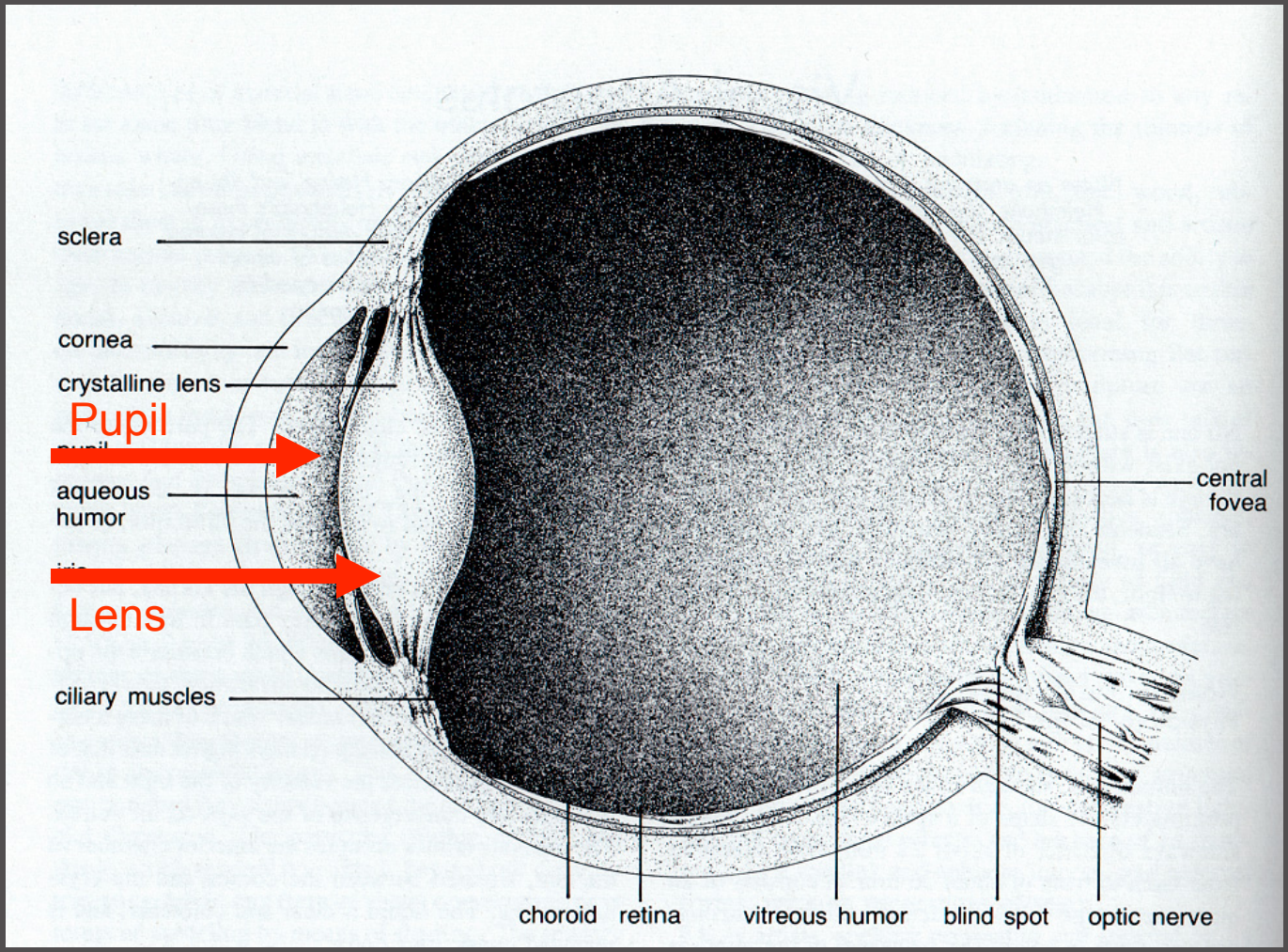
The ratio of nerve to muscle is 1:2 where in the rest of the body the ratio is 1:200.

From the day you are born your eye is always changing. The eye is constantly deteriorating.



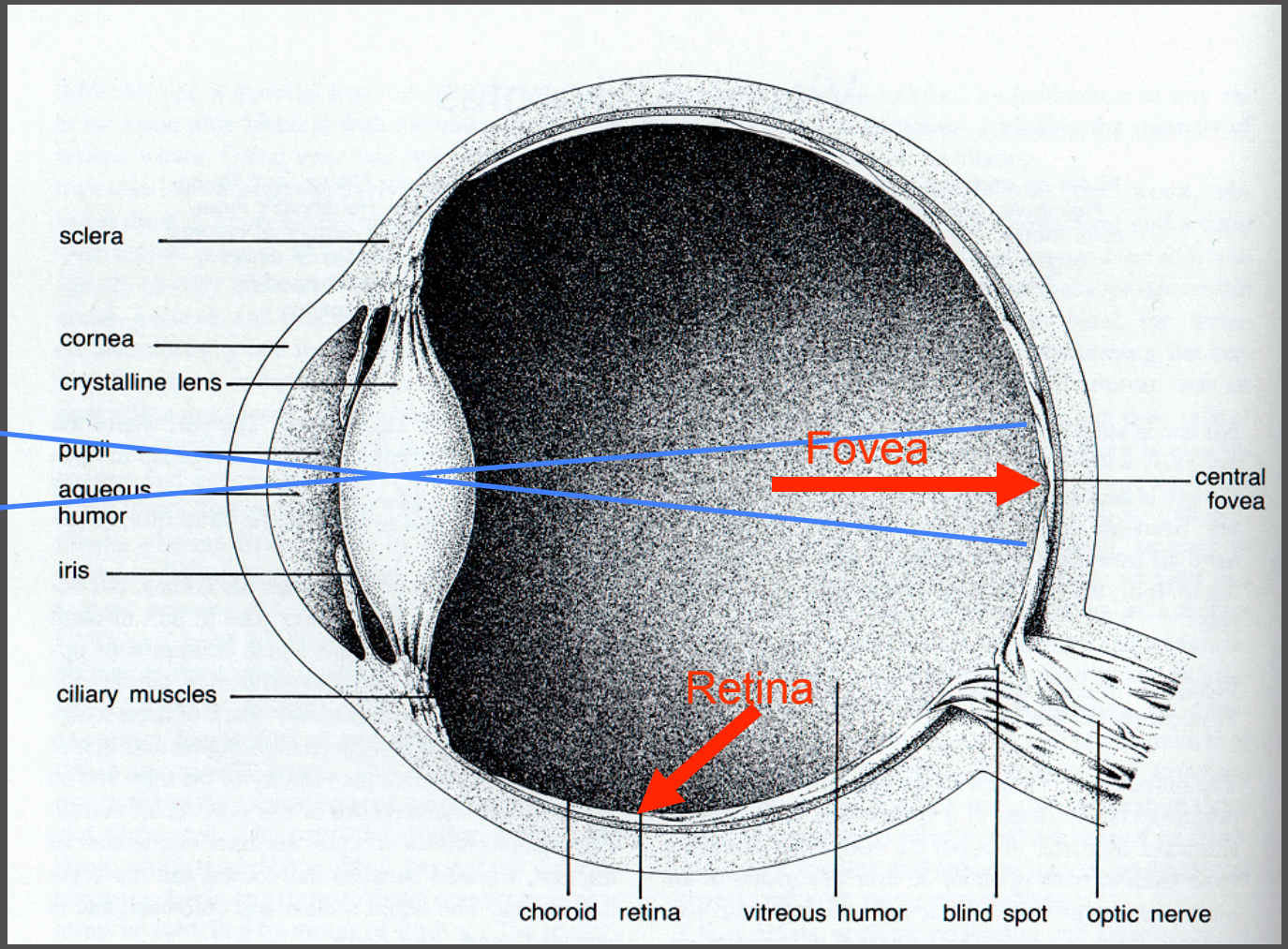
Cornea-- is the transparent membrane that bends light as it passes through the Iris. The cornea is the reason we can not see U.V. and infra-red. It restricts those types of electromagnetic radiation.

Iris-- is what gives the color to the eye. The Iris is made of muscles that expand and contract to control the amount of light entering the eye through the pupil.



- Pupil-- the hole in the donut. corresponds to the aperture in a camera. Regulating the amount of light.

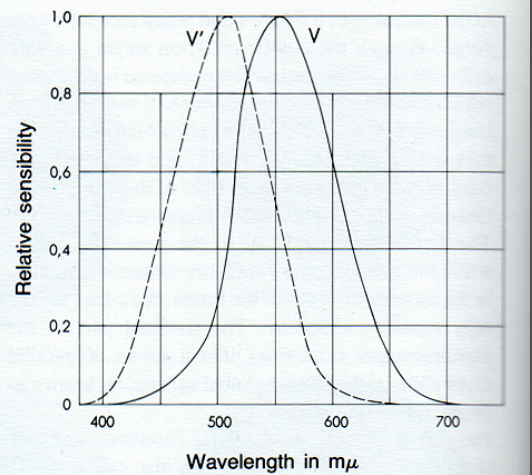
- Lens-- rest on the edge of the iris. It is the size of a lima bean and consist of crystalline structure. The muscles of the iris bend the lens to allow one to focus.



- Retina-- inner lining of the eye, (like the film in a camera) Acute vision takes place in the center of the retina called the fovea. (Made of rods and cones.)

- The fovea is made of cones only. The blind spot is where the optic nerve connects to the eye.

The Eye and Vision - Rods and Cones



5-6. Curve of spectral sensibility in relation to rods (V´) and cones (V)

- Rods-- allow one to see in low light condition and make up the largest amounts of receptors in the eye (around 30 million)

-

- Cones-- allow one to see color. We have three different types of cones to see the three primary colors. The fovea is made of cones only, this allows one to see detail well in color, but makes a blind spot under dark conditions.

The Eye and Vision - Rods and Cones

- Rods-- allow one to see in low light condition and make up the largest amounts of receptors in the eye (around 30 million) The rods only allow you to see:
  - black and white.
  - better night vision
  - poor visual acuity
  - 1/3 fc-1/100 fc
  - black and white only
  - vision increases in periphery
- Cones-- allow one to see color. We have three different types of cones to see the three primary colors. The fovea is made of cones only, this allows one to see detail well in color, but makes a blind spot under dark conditions.
  - better day vision
  - very good visual acuity **Why?**
  - 1/3 fc- 10,000 fc.
  - color
  - decreases in periphery

The Eye and Vision

- Light Adaptation (Photopic Vision) When you move from a dark environment to a light environment. (Turning on the lights quickly after a power point presentation.)

  Painful, but not harmful. Happens very quickly.

- Dark Adaptation (Scotopic Vision) When you move from a light environment to a dark environment.

  Dark adaptation is a slow process. May take 20 minutes. (Why would this be important to interior designers?)

The Eye and Vision

VISUAL ACUITY

The measure of ones ability to see fine detail. This ability to see fine detail decreases with age. Visual acuity is based on five factors:

Visual Angle

Luminance

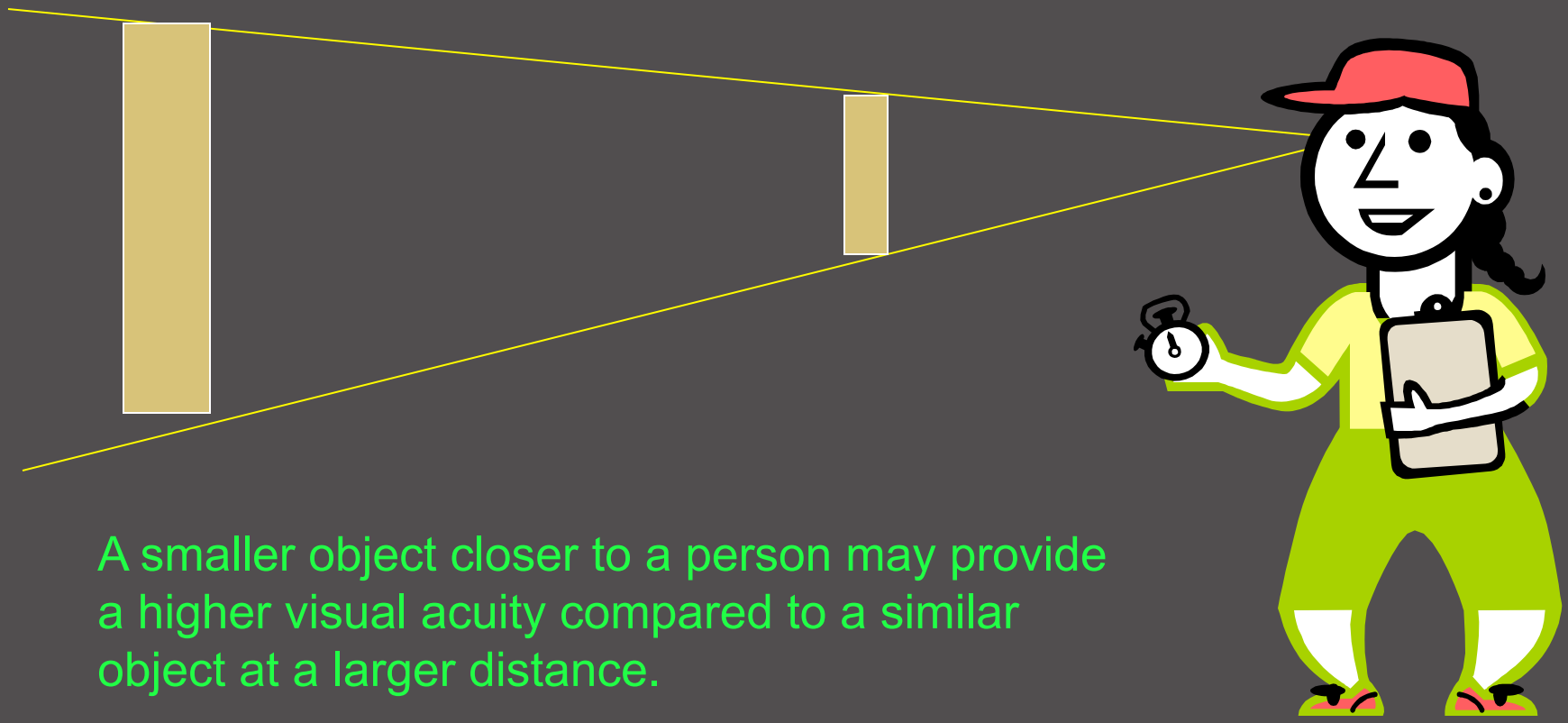
Time

Contrast

Color

VISUAL ACUITY VISUAL ANGLE

The visual angle, not the size, may determine the visual acuity of an object.



A smaller object closer to a person may provide a higher visual acuity compared to a similar object at a larger distance.

The larger the visual angle the greater the visual acuity.

VISUAL ACUITY - LUMINANCE

The amount of light falling on the surface of an object can influence visual acuity.

I. Illuminance Categories and Illuminance Values for Generic Types of Activities in Interiors

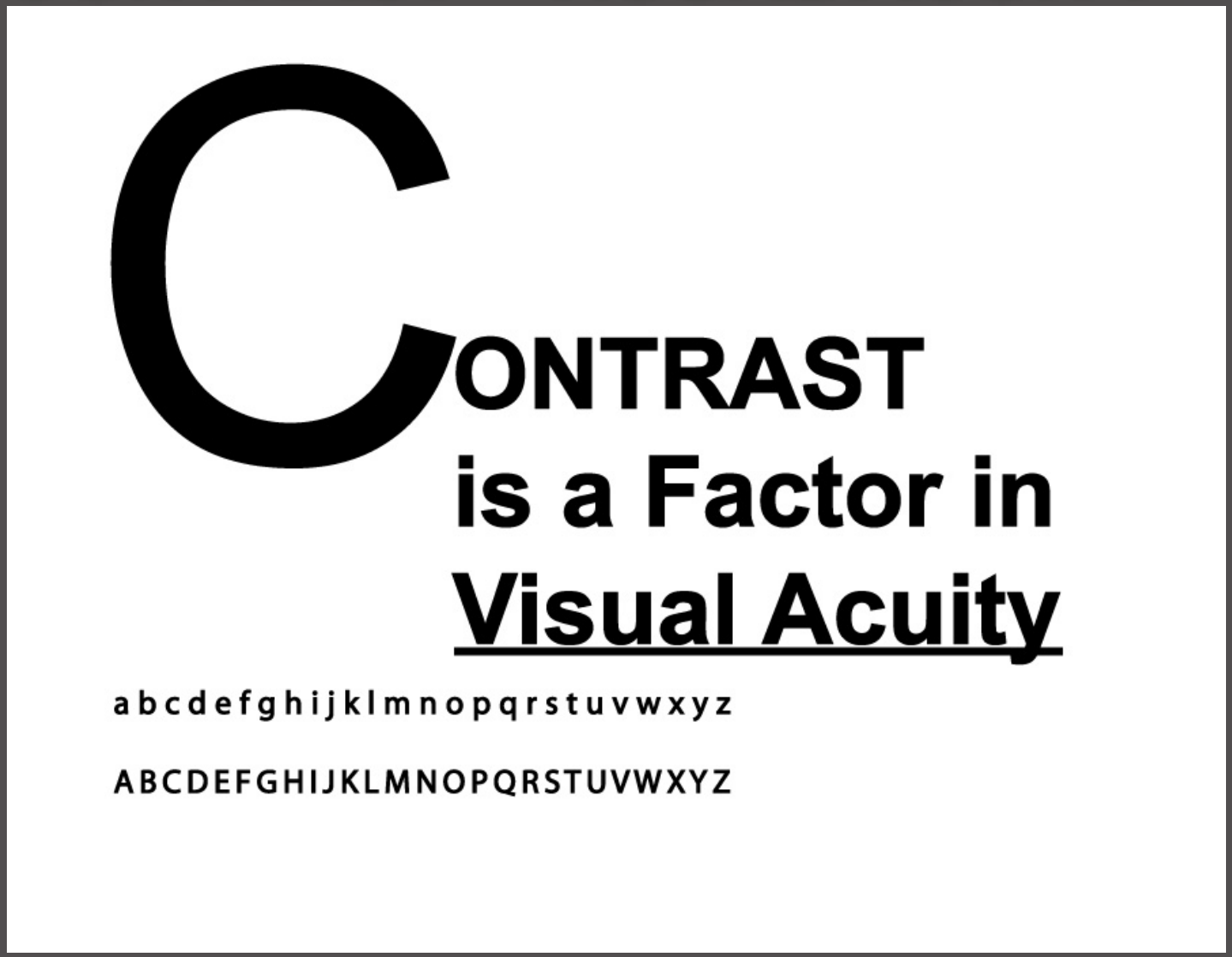
Type of Activity	Illuminance Category	Ranges of Illuminances		Reference Work-Plane
		Lux	Footcandles	
Public spaces with dark surroundings	A	20-30-50	2-3-5	General lighting throughout spaces
Simple orientation for short temporary visits	B	50-75-100	5-7.5-10	
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	Illuminance on task
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	
Performance of visual tasks of low contrast or very small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	Illuminance on task, obtained by a combination of general and local (supplementary lighting)
Performance of very prolonged and exacting visual task	H	5000-7500-10000	500-750-1000	
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

CONTRAST - VISUAL ACUITY

The ratio of light reflected on the background and the object can influence the visual acuity.

The higher the ratio (high contrast) the higher the visual acuity.

CONTRAST - VISUAL ACUITY



CONTRAST - VISUAL ACUITY

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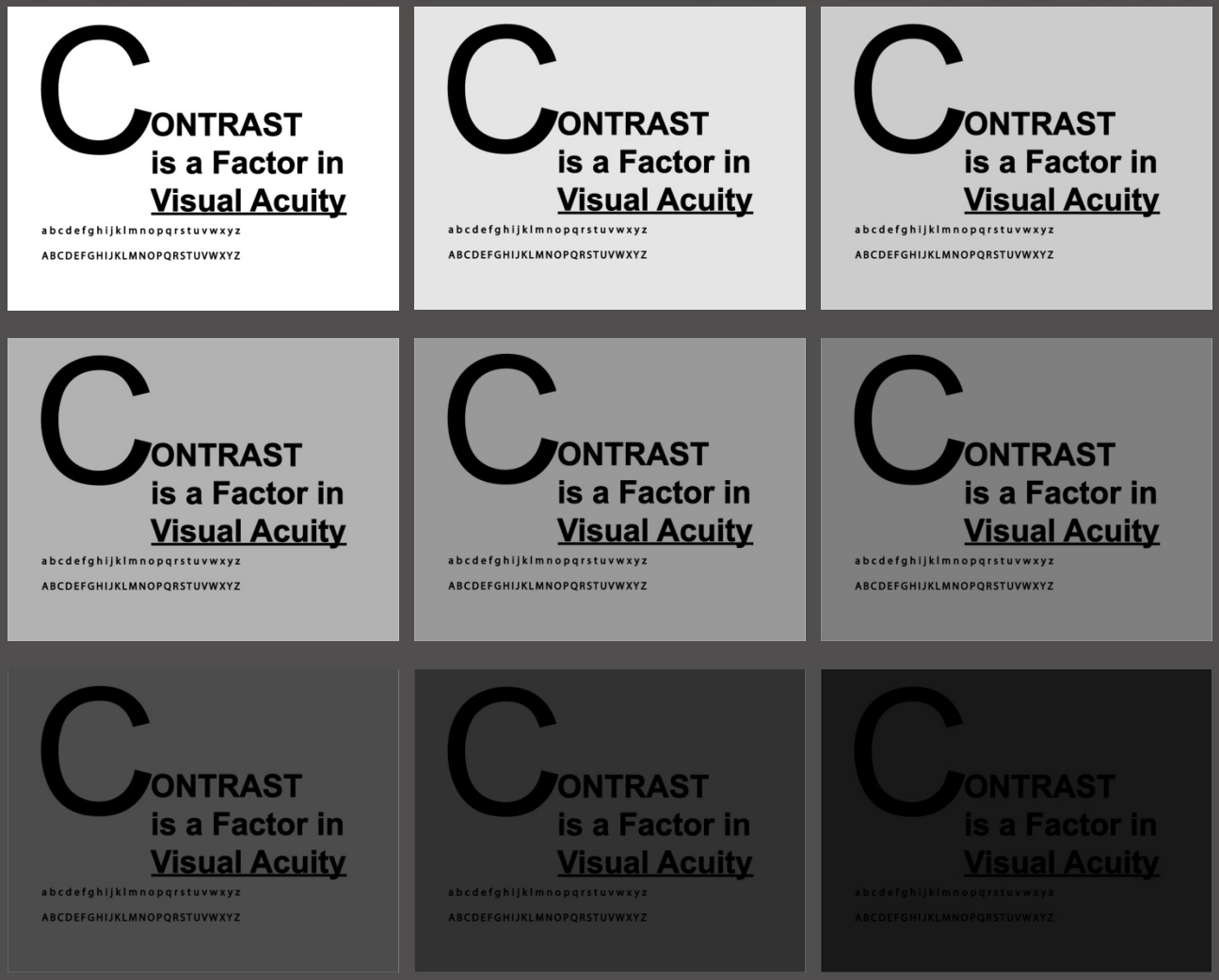

CONTRAST - VISUAL ACUITY

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COLOR - VISUAL ACUITY

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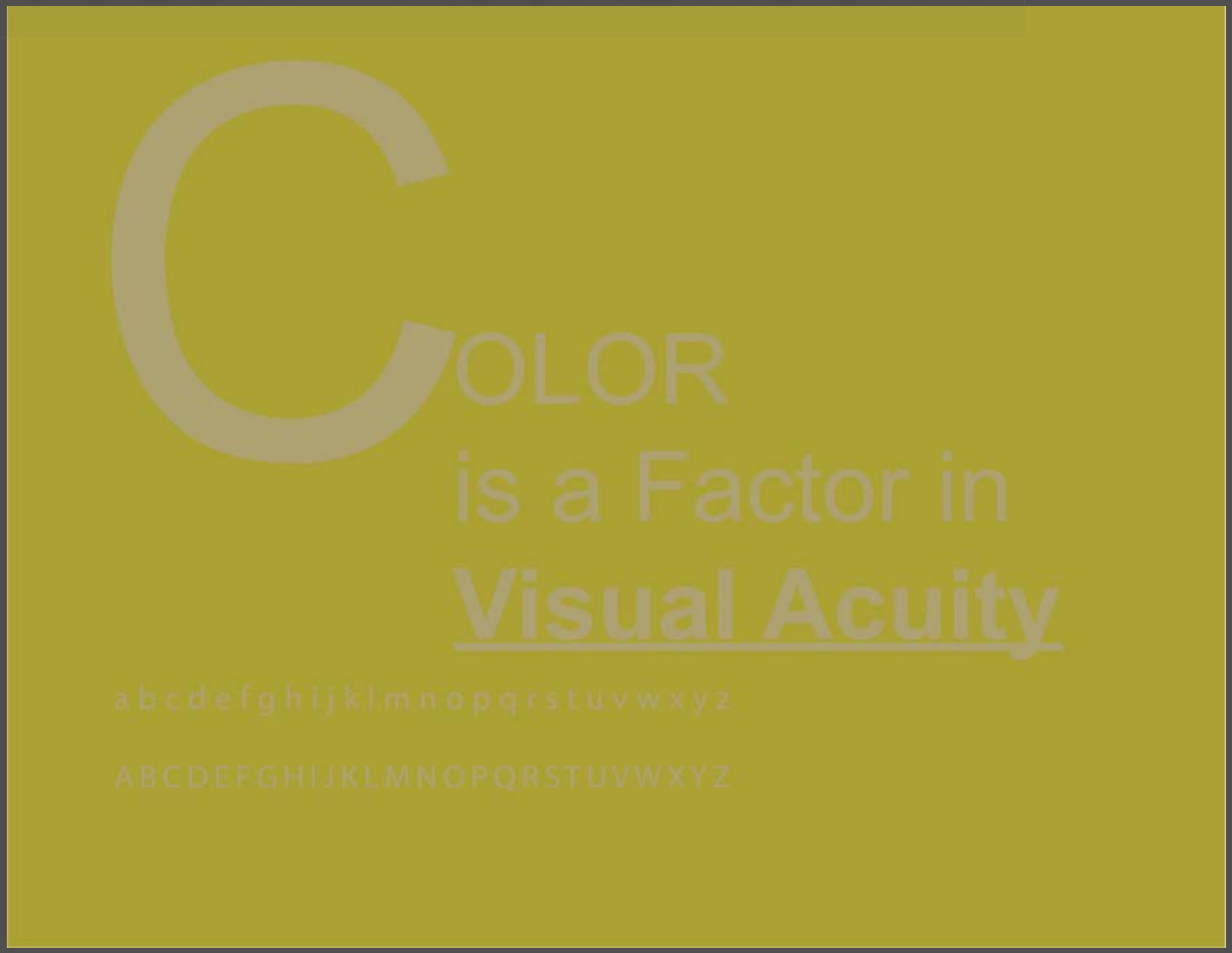

COLOR - VISUAL ACUITY

COLOR
is a Factor in
Visual Acuity

a b c d e f g h i j k l m n o p q r s t u v w x y z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

COLOR - VISUAL ACUITY

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A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

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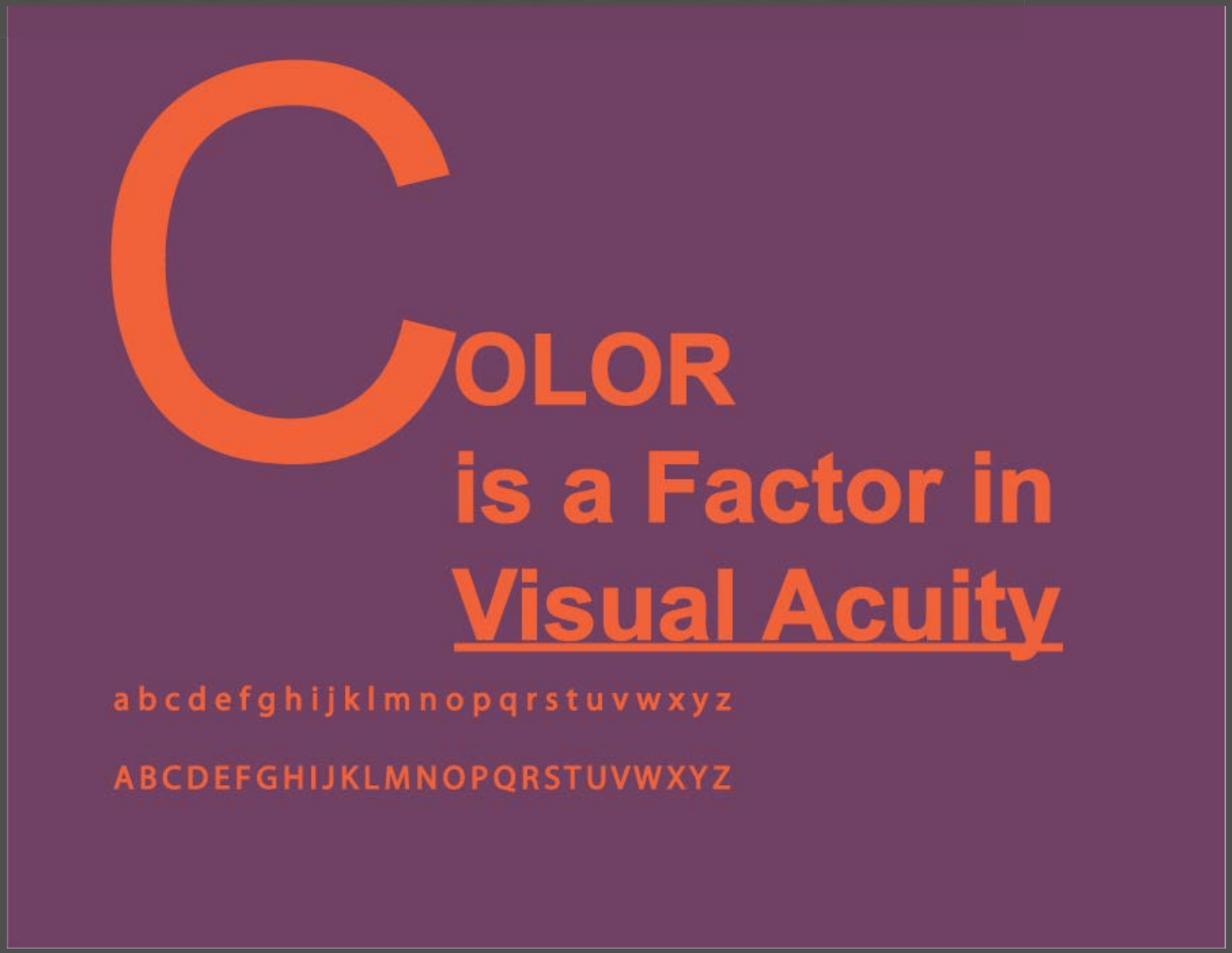

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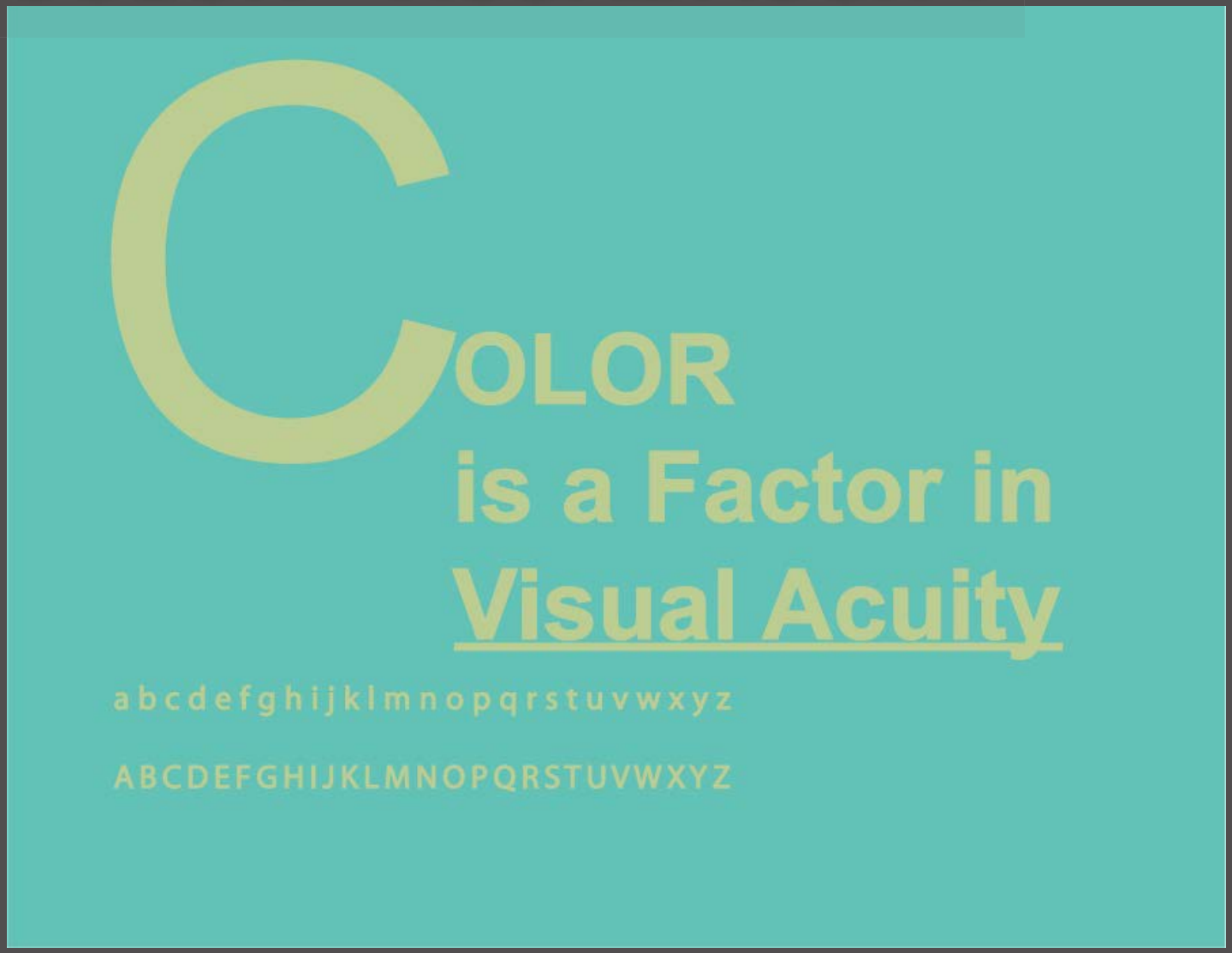


COLOR - VISUAL ACUITY

COLOR
is a Factor in
Visual Acuity

a b c d e f g h i j k l m n o p q r s t u v w x y z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

COLOR - VISUAL ACUITY

COLOR
is a Factor in
Visual Acuity

a b c d e f g h i j k l m n o p q r s t u v w x y z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

COLOR - VISUAL ACUITY

COLOR & VISUAL ACUITY

COLOR - VISUAL ACUITY

VISUAL ACUITY - TIME

Time-- Seeing is not instantaneous, given enough time we can see much under poor lighting conditions. (Vision is a photochemical process.)

How does time and light relate to productivity on an assembly line?

VISIBILITY

Visibility is the quality or state of being perceivable by the eye. Ability to distinguish details against a background creates high visibility.

Speed and accuracy are involved in work environments.

People have a great ability to adapt under adverse lighting conditions, just because we can see in lighting conditions that may not be optimal.

LIGHT QUALITY

Some of the most important issues in work environments that will effect the quality of light is glare and luminance ratios.

You should always keep in mind that more light does not equal better light.

LIGHT QUALITY LUMINANCE RATIOS.

In an office space IES recommends that luminance ratios do not exceed 1:5.

The means that if the darkest surface is 25 foot candles the most illuminated surface should not exceed 125 foot candles. (25fcX5=125fc)

A high luminance greater than 1:5 may create visual fatigue. Our eyes are having to constantly adjust to bright and dim light.

LIGHT QUALITY LUMINANCE RATIOS.

One may think that a low ratio, 1:1 or 1:2 may be better.

Research indicate that we need some difference in luminance in the range of 1:4 or 1:5 to create visual interest within the spaces we work.

A ratio of 1:1 would provide the same amount of light on all surfaces.

LIGHT QUALITY LUMINANCE RATIOS.

To make something STAND OUT, or be noticed as separate,

To notice a difference in lighting levels luminance ratios are in the range of 1:2. This means twice the light on an object if you want it to stand out from the background/ambient visual field.

In an office space IES recommends that luminance ratios do not exceed 1:5. More visual contrast than 1:5 causes a harsh visual environment.

To create visual interest and attraction a luminance ratio of 1:10 or higher. (Store displays.) To make a vase of flowers really stand out, it needs to be lit with a brightness that is TEN times the ambient light level.

Light Quality Luminance Ratios.

Accent Lights to add visual interest.

Light Quality Luminance Ratios.

Accent Lights to add visual interest.

LIGHT QUALITY GLARE.

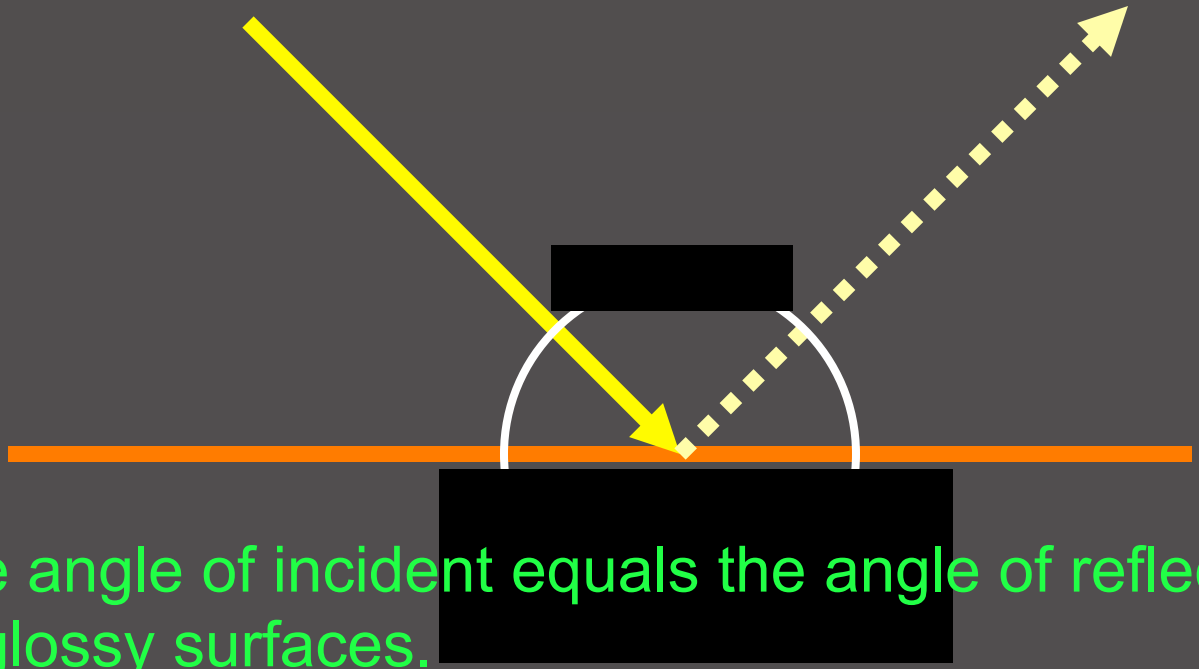
Glare is any excessively bright light source that causes visual discomfort or a loss in visibility.

Direct glare is caused by looking directly into a bright light source.

Reflected Glare-- Any excess bright source reflecting off a shiny or mirror surface.

Veiling Reflections-- Improper placed bright light source that reflects off a matte task causing a loss in contrast or visibility.

LIGHT QUALITY GLARE.

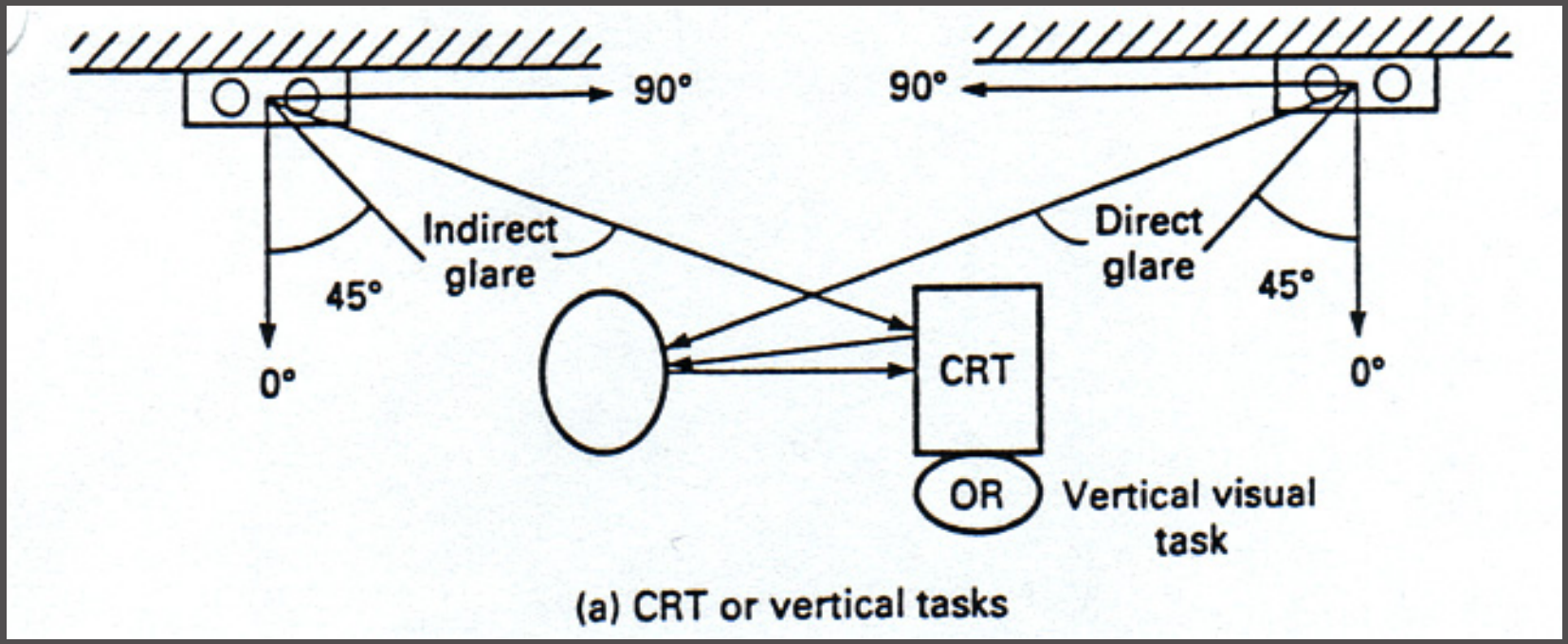


The angle of incident equals the angle of reflection in ãmirrorä or glossy surfaces.

Mirror and or glossy surfaces can lead to problems with glare. (Computer monitors)

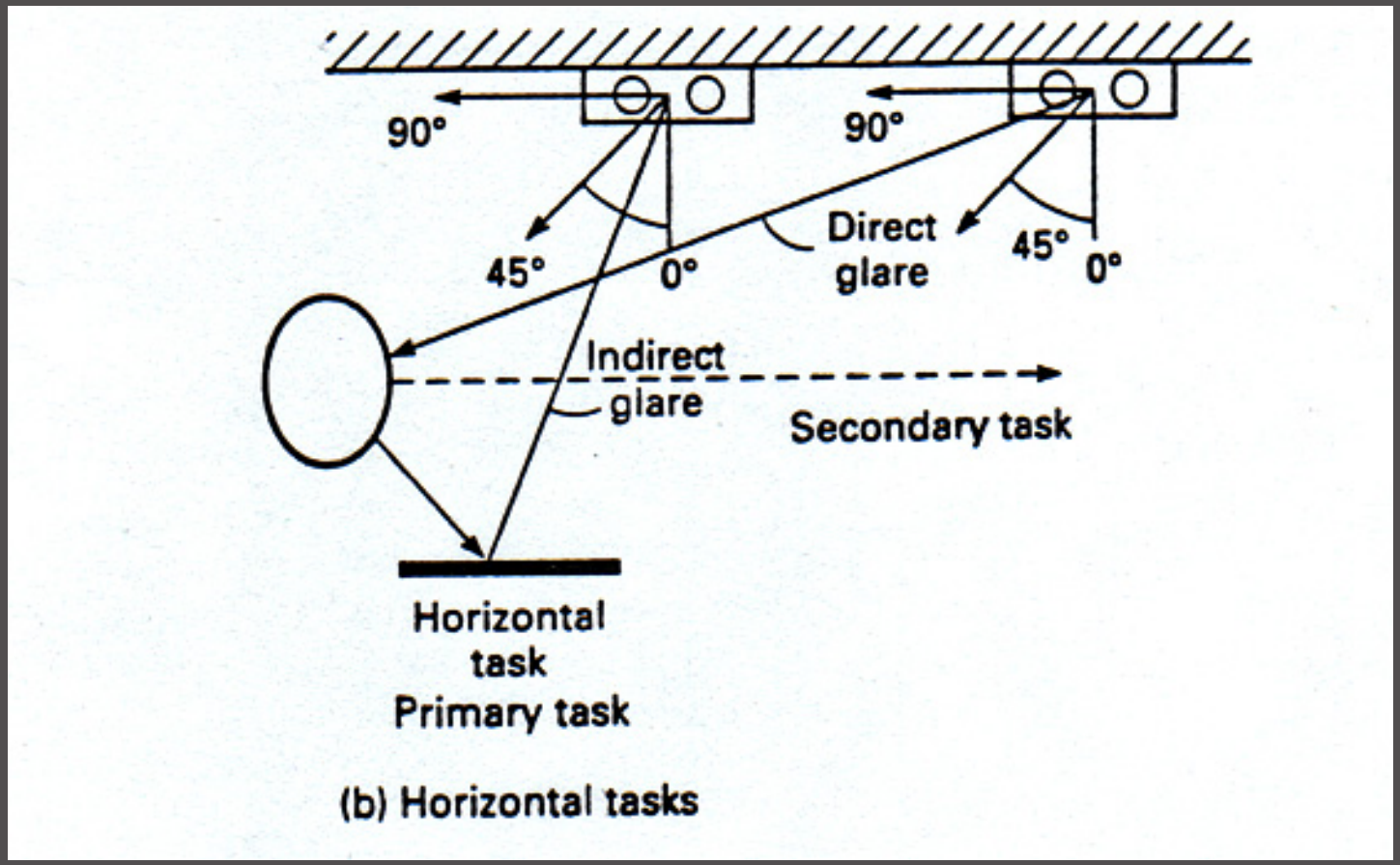
Office spaces need to be designed to reduce visibility of directly looking into light sources (direct glare) and reduce the ability to see the angle of reflection.

LIGHT QUALITY GLARE.



Vertical Tasks (Computer Monitors)

LIGHT QUALITY GLARE.



Horizontal Tasks

LIGHT QUALITY GLARE.

Typical office floor, Union Carbide Building, 1960; New York, New York; Architect: Skidmore, Owings & Merrill; Photographer: Ezra Stoller © Esto

LIGHT QUALITY GLARE.

LIGHT QUALITY GLARE.

LIGHT QUANTITY IES GUIDELINES.

Process of estimating the correct illuminance values for tasks.

1. Select or estimate the closest task in the IES guidelines. (Figure 43 Section II)
2. Record the illuminance category.
3. Estimate the following factors of the space as high, medium or low in terms of visual acuity.

   A. If category A - C

      - Age of occupants

      - Reflectance Values in the room

   B. If category D - I

LIGHT QUANTITY IES GUIDELINES.

4. Using Figure 56. from the IES Guidelines weight the factors.

Fig. 56. Weighting Factors to be Considered in Selecting Specific Illuminance Within Ranges of Values for Each Category.

a. For Illuminance Categories A through C

Room and Occupant Characteristics	Weighting Factor		
	−1	0	+1
Occupants ages	Under 40	40–55	Over 55
Room surface reflectances*	Greater than 70 per cent	30 to 70 per cent	Less than 30 per cent

b. For Illuminance Categories D through I

Task and Worker Characteristics	Weighting Factor		
	−1	0	+1
Workers ages	Under 40	40–55	Over 55
Speed and/or accuracy**	Not important	Important	Critical
Reflectance of task background***	Greater than 70 per cent	30 to 70	Less than 30 per cent

5. Add the points of the factors.

LIGHT QUANTITY IES GUIDELINES.

6. Using chart I. in figure 43 weight the illumination level in the following manner. If the points add to one or more use the high illumination level. If the points add to 0 then use the medium illumination level. If the factors add to less than zero then use the low illumination levels.

I. Illuminance Categories and Illuminance Values for Generic Types of Activities in Interiors

Type of Activity	Illuminance Category	Ranges of Illuminances		Reference Work-Plane
		Lux	Footcandles	
Public spaces with dark surroundings	A	20-30-50	2-3-5	General lighting throughout spaces
Simple orientation for short temporary visits	B	50-75-100	5-7.5-10	
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	Illuminance on task
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	
Performance of visual tasks of low contrast or very small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	Illuminance on task, obtained by a combination of general and local (supplementary lighting)
Performance of very prolonged and exacting visual task	H	5000-7500-10000	500-750-1000	
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

LIGHT QUANTITY IES GUIDELINES.

What would be the recommended illumination level for a courtroom seating area? The materials in the courtroom are dark and occupants will be in a range of ages from young to elderly?

II. Commercial, Institutional, Residential and Public Assembly Interiors

Area/Activity	Illuminance Category
Accounting (see **Reading**)	
Air terminals (see **Transportation terminals**)	
Armories	C[1]
Art galleries (see **Museums**)	
Auditoriums	
Assembly	C[1]
Social activity	B
Banks (also see **Reading**)	
Lobby	
General	C
Writing area	D
Tellers' stations	E[3]
Barber shops and beauty parlors	E
Churches and synagogues (see Fig. 45)[4]	
Club and lodge rooms	
Lounge and reading	D
Conference rooms	
Conferring	D
Critical seeing (refer to individual task)	
Court rooms	
Seating area	C
Court activity area	E[3]
Dance halls and discotheques	B
Depots, terminals and stations (see **Transportation terminals**)	

For footnotes, see page 102.
*In IES Lighting Handbook, *1987 Application Volume*. Also see Fig. 56 and Fig. 75 (inside back cover).

Record Category C

LIGHT QUANTITY IES GUIDELINES.

Weight the illumination levels. (Use part a. of figure 56)

Occupants ages +1

Room Reflectances +1

Total Weighted Factors = +2

Fig. 56. Weighting Factors to be Considered in Selecting Specific Illuminance Within Ranges of Values for Each Category.

a. For Illuminance Categories A through C

Room and Occupant Characteristics	Weighting Factor		
	−1	0	+1
Occupants ages	Under 40	40–55	Over 55
Room surface reflectances*	Greater than 70 per cent	30 to 70 per cent	Less than 30 per cent

b. For Illuminance Categories D through I

Task and Worker Characteristics	Weighting Factor		
	−1	0	+1
Workers ages	Under 40	40–55	Over 55
Speed and/or accuracy**	Not important	Important	Critical
Reflectance of task background***	Greater than 70 per cent	30 to 70	Less than 30 per cent

LIGHT QUANTITY IES GUIDELINES.

6. Using chart I. in figure 43 you would select the highest illumination level for category C.

I. Illuminance Categories and Illuminance Values for Generic Types of Activities in Interiors

Type of Activity	Illuminance Category	Ranges of Illuminances		Reference Work-Plane
		Lux	Footcandles	
Public spaces with dark surroundings	A	20-30-50	2-3-5	
Simple orientation for short temporary visits	B	50-75-100	5-7.5-10	General lighting throughout spaces
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	Illuminance on task
Performance of visual tasks of low contrast or very small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	
Performance of very prolonged and exacting visual task	H	5000-7500-10000	500-750-1000	Illuminance on task, obtained by a combination of general and local (supplementary lighting)
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

20 Footcandles

LIGHT QUANTITY IES GUIDELINES.

What would be the recommended illumination level for reading low contrast blue prints. (Old and worn blue prints)

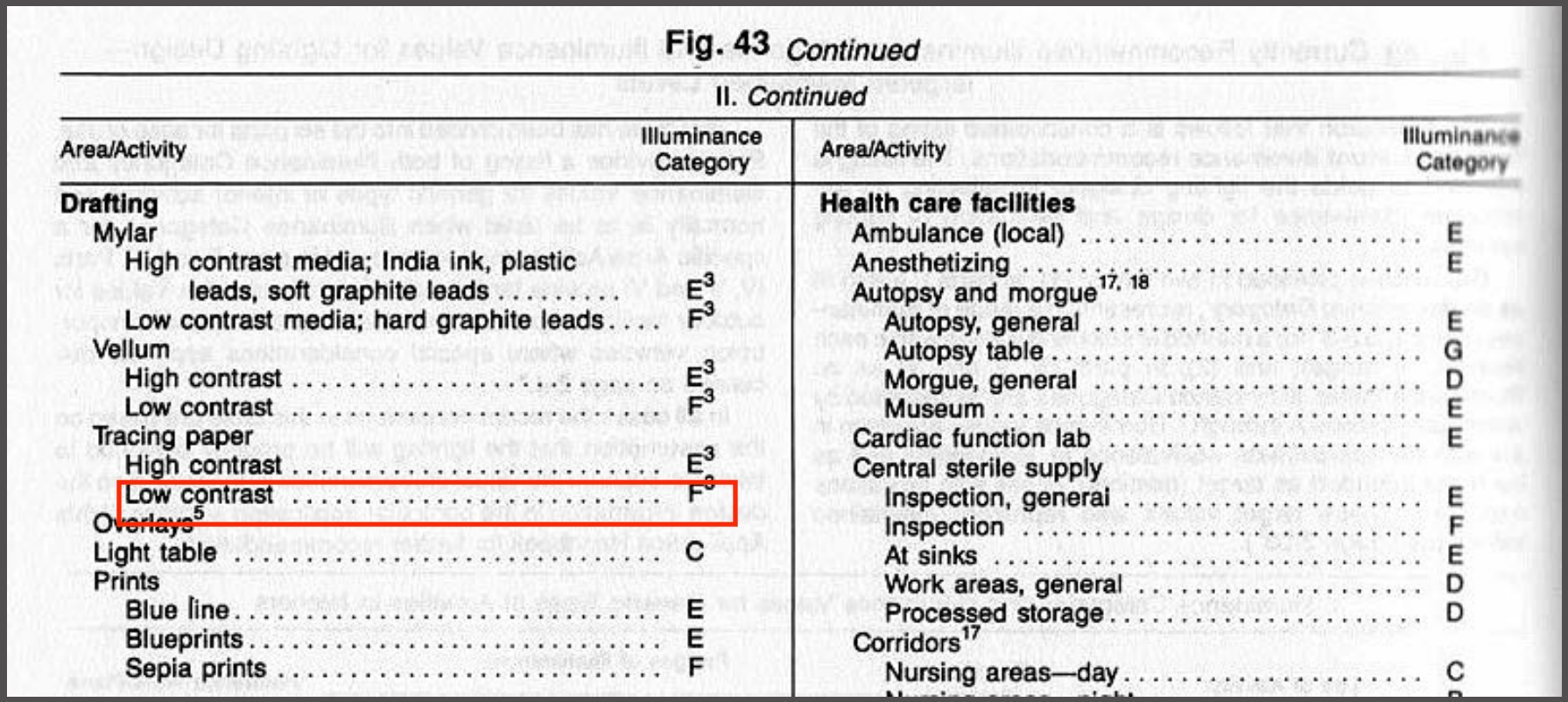


Fig. 43 *Continued*

II. *Continued*

Area/Activity	Illuminance Category
Drafting	
Mylar	
High contrast media; India ink, plastic leads, soft graphite leads	E[3]
Low contrast media; hard graphite leads	F[3]
Vellum	
High contrast	E[3]
Low contrast	F[3]
Tracing paper	
High contrast	E[3]
Low contrast	F[3]
Overlays[5]	
Light table	C
Prints	
Blue line	E
Blueprints	E
Sepia prints	F

Area/Activity	Illuminance Category
Health care facilities	
Ambulance (local)	E
Anesthetizing	E
Autopsy and morgue[17, 18]	
Autopsy, general	E
Autopsy table	G
Morgue, general	D
Museum	E
Cardiac function lab	E
Central sterile supply	
Inspection, general	E
Inspection	F
At sinks	E
Work areas, general	D
Processed storage	D
Corridors[17]	
Nursing areas—day	C

Record Category E

LIGHT QUANTITY IES GUIDELINES.

Weigh the factors in Figure 56.

Fig. 56. Weighting Factors to be Considered in Selecting Specific Illuminance Within Ranges of Values for Each Category.

a. For Illuminance Categories A through C

Room and Occupant Characteristics	Weighting Factor		
	−1	0	+1
Occupants ages	Under 40	40–55	Over 55
Room surface reflectances*	Greater than 70 per cent	30 to 70 per cent	Less than 30 per cent

b. For Illuminance Categories D through I

Task and Worker Characteristics	Weighting Factor		
	−1	0	+1
Workers ages	Under 40	40–55	Over 55
Speed and/or accuracy**	Not important	Important	Critical
Reflectance of task background***	Greater than 70 per cent	30 to 70	Less than 30 per cent

0 for workers ages.

0 for speed and accuracy

+1 for reflectance of task background (Old, low contrast blue prints.)

LIGHT QUANTITY IES GUIDELINES.

6. Using chart I. in figure 43 you would select the highest illumination level for category E.

I. Illuminance Categories and Illuminance Values for Generic Types of Activities in Interiors

Type of Activity	Illuminance Category	Ranges of Illuminances		Reference Work-Plane
		Lux	Footcandles	
Public spaces with dark surroundings	A	20-30-50	2-3-5	General lighting throughout spaces
Simple orientation for short temporary visits	B	50-75-100	5-7.5-10	
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	Illuminance on task
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	
Performance of visual tasks of low contrast or very small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	Illuminance on task, obtained by a combination of general and local (supplementary lighting)
Performance of very prolonged and exacting visual task	H	5000-7500-10000	500-750-1000	
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

100 Footcandles

LIGHT QUANTITY IES GUIDELINES.

In groups of three find the illumination level for the following tasks and activities.

1. A dance club for a young crowd. Estimate reflectance values of space.
2. Cutting surface in a residential kitchen for a young family. The color of the cutting board is white.
3. Feature display of computers in a retail store. The display is in a very active part of the store.
4. A prosthetic laboratory for a dental office. The senior lab worker is 62 years old.
5. A passenger elevator in a senior center. The elevator is finished in a walnut veneer.
6. Using a computer workstation in a library for research. The ceiling in the room is painted black.
7. Reception area in an office. Surfaces are white.