

**48-410 Acoustics and Lighting
Fall 2008**

Monday, Wednesday, 12:30-13:20
DH A310 (lectures)
Hunt Lower Level (Software Sessions)

Lecture 6: Lighting Design

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Office Hours: Wed 18:00-19:00

Carnegie Mellon
Pittsburgh, Pennsylvania

Class Plan

- Quantitative Lighting Design
- Luminance-based Approach
- Information-based Approach
- Qualitative Lighting Design

References

[IESNA Lighting Handbook 9th Edition](#), Illuminating Engineering Society of North America, 2000.

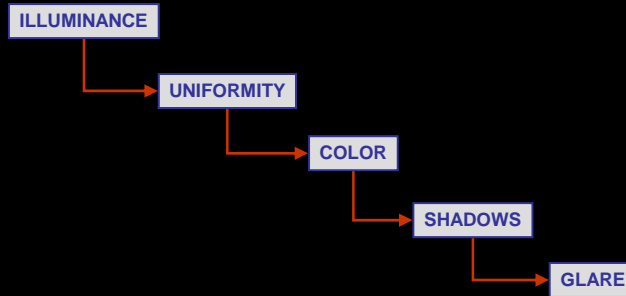
ERCO Guide – Architectural Lighting

http://www.erco.com/guide_v2/guide_2/designing_w_90/designing_w_90/en/en_designing_w_prog_1.htm

Quantitative Lighting Design

Performance Approach

- Optimum visual performance
- High Productivity
- Safety
- Cost



Quantitative Lighting Design

Illuminance

- Exponential response
- Adjustment by "half steps"
 - Is the task detail significantly smaller than normal?
 - Is the task contrast significantly lower than normal?
 - Is the consequence of error unusually serious?
 - Are the tasks carried out for longer periods than usual?
 - Do the users have poorer eyesight?
- Lumen maintenance of lamps
- Maintenance factors
- Surface Brightness
 - Luminance and Illuminance
 - Surface Constancy
 - Brightness Vs Lightness

TASK REQUIREMENT	EXAMPLE	GUIDELINE ILLUMINANCE
General lighting Simple visual tasks	Access routes	50
	Staircases, corridors	100
	Bathrooms	150
	Foyers, lobbies	200
General Lighting Working spaces	Classrooms	300
	General Offices	500
	Drawing offices, studios	700
Lighting for complicated visual tasks (small detail and low contrast)	Electronic Assembly	1000
	Fine Work and Inspection Assembly of minute mechanisms	1500 2000

Quantitative Lighting Design

Uniformity

- Overall lighting too bright for other activities?
- Effect on spatial character?



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Quantitative Lighting Design

Color

- Hue, Chroma, Value
 - Which Hue?
 - Warm Vs Cool (Formal, cultural, character ..etc)
 - Expectations of color (time, associations ..etc)
 - Color Schemes
 - Color Contrast
 - Color Rendering
 - Integration/Emphasis on zones/activity/time
 - Dependent on brightness
 - What Chroma?
 - Perceptual associations (carnival, institutional ..etc)
 - Expectations
 - Dependent on size
 - What Value?
 - Integration/Emphasis on zones/activity/time
 - Pattern and character
 - Contrast



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Quantitative Lighting Design – Case Study

Design Horizontal illuminance for reading tasks and visual comfort

- Vertical illuminance for TV broadcasting
 - Groups of spotlights for each segment of room
 - Avoid shadows from structure
 - Avoid glare in faces of speakers
- Integration of daylight with artificial light
 - Blinds to diffuse daylight
 - 4200K Metal halide lamps for color consistency



200 spotlights positioned via simulation



Scottish Parliament, Holyrood, Edinburgh
 Architect: Enric Miralles
 Lighting Consultant: Office for Visual Interaction (OVI), NY

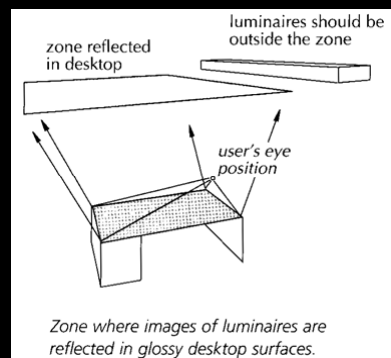
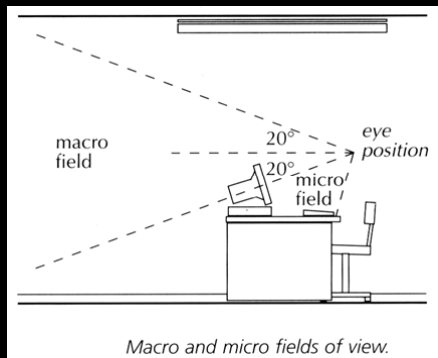
Quantitative Lighting Design

Shadows

- Texture, character, visual interest
- Task performance, additional task lighting

Glare

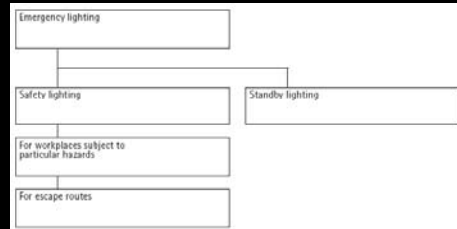
- Task performance, repositioning lamps
- Direct glare and Veiling reflections



Quantitative Lighting Design

Safety

- Way finding
- Complete activities
 - Duration
 - Illuminance/Luminance
 - Location
 - Expected environment conditions



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Luminance-based Approach

Appearance / Perception instead of simple illumination quantities

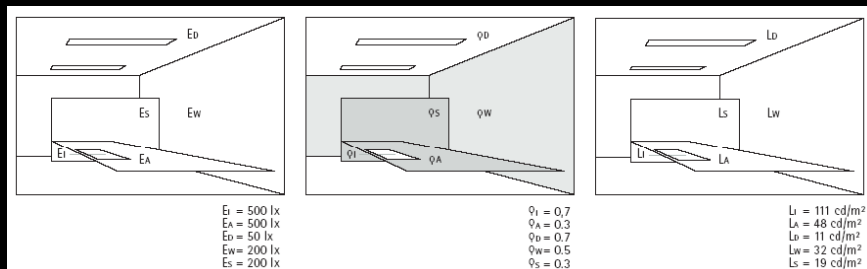
- Not only adequate lighting but also optical effect (human perception)

Brightness and Contrast ratios (basis of perception)

- Artificial & daylight have different effects (latter higher tolerance)
- Visual interest (higher tolerance)

Finer granularity of lighting planning for a space

- From single task in space to visual requirements in visual environment
- Zones
- Using ratios



Within task → 1:3 (or 3:1)
 Task : Adjacent surround → 3:1 (or 3:1)
 Task : Remote surfaces → 1:10 (or 10:1)

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Information-based Approach

Light as a medium for imparting information

- Ambient Light
 - General illumination for orientation and performing tasks
 - Overall, uniform (diffused)
- Differentiated Lights
 - Focal Glow
 - Active participant in conveying information
 - Draws attention to information
 - Hierarchy of brightness, sequence of delivering information
 - Fast and accurate flow of information transfer
 - Orientation, emphasis ..etc
 - Play of Brilliance
 - Representation of information by light itself
 - Specular effects (chandeliers, caustics ..etc)
 - Character, associations, effects.



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Information-based Approach

Information as narrative

- Lighting to help people perceive
 - Character of space
 - Architectural Fabric
 - Objects on display
 - Perform visual tasks
 - See other people



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Information-based Approach – Case Study

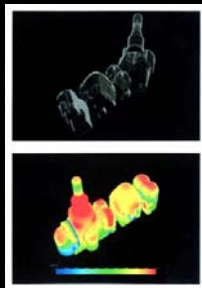
Display frescos and opulent ornamentations

- High CRI tungsten-halogen
- High CRI metal halide
- Warm brilliance on gold ornamentations

Discreet installation locations

- On the chains of candelabra
- On capitals and cornices

Simulations to ensure appropriate illuminance



The Church in Putna Monastery
 Founded c.1653, renovated 2004
 Electrical Planning: ProEnerg, Oradea, Romania



Information-based Approach – Case Study

Play of Brilliance

Original installations – narrow-beam halogens focused on filigree support

New product – miniaturized metal halide, similar size and geometry but higher lumen output and color temperature but lower wattage

Le Grand Louvre, Paris
 Architect: I.M. Pei (1989, Renovated 2004)
 Lighting designers: Claude Engle, Chevy Chase MD

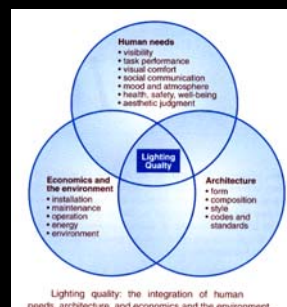


Qualitative Lighting Design Approach

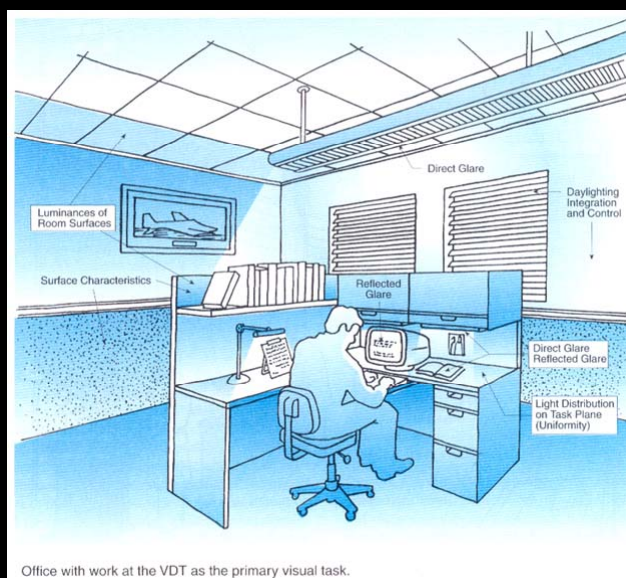
Quality of lighting, as measured by satisfaction of human needs.

Considerations

- Appearance of Space / Luminaire (visual cues, associations ..etc)
- Color Appearance / Contrast
- Daylighting
- Glare
- Flicker
- Illuminance and Luminance (Horizontal / Vertical)
- Material / Surface characteristics
- Light Distribution and Patterns
- Uniformity on task plane
- Light pollution
- Luminaire noise
- Modeling objects (Depth / Shape / Texture)
- Peripheral Detection
- Points of interest
- Shadows
- Specular effects
- System control / flexibility

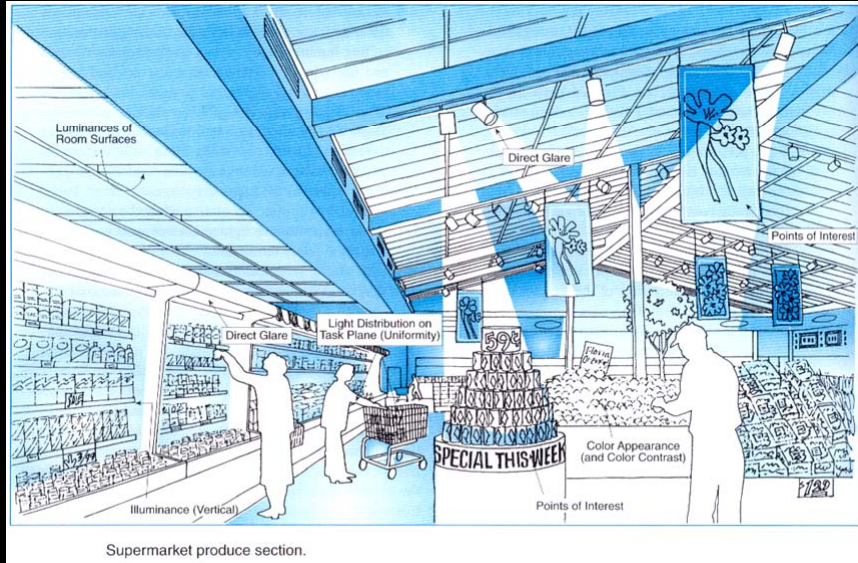


Qualitative Lighting Design Approach



Office with work at the VDT as the primary visual task.

Qualitative Lighting Design Approach



Supermarket produce section.

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Qualitative Lighting Design Approach

Interior-3

IESNA Lighting Design Guide

I. INTERIOR LOCATIONS AND TASKS	Legend																							
	Very important	Important	Somewhat important	Blank = Not important or not applicable																				
Design Issues	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source(s)/Task/Eye Geometry	Sparkle/Discrete Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)
Correctional Facilities																								
Cells																			D	B		(4)	Ch. 14	
Day rooms																			D	B				
Corridors (see Service Spaces)																								
Court Rooms (see Reading)																							Ch. 14	
Seating area (spectators)																				C	A			
Judge and clerk																				E	C		(9)	
Litigant's table																				m	C		(6)	
Podium																				m	C		(5)	
Witness chair																				D	B			
Dance Halls/Discotheques																								
Dance halls/discotheques																				A	A			
Ballrooms/social events																				B	A			
Depots, Terminals, Stations (see Transportation Terminals in Section V, Transportation)																							Ch. 23	
Drafting/Graphic Arts																								
CAD stations only																				C	A			
Mixed CAD and paper task																				D	A			

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Qualitative Lighting Design

Architectural Lighting

- Ambient Lighting
 - Defines spatial appearance / character
 - Forming spatial zones and borders
 - Establish continuity
- Accent Lighting
 - Emphasis on element
 - Establish hierarchy
- Task Lighting
 - Satisfy functional requirements
 - Orientation and safety
- Decorative Lighting
 - Narrative and effects

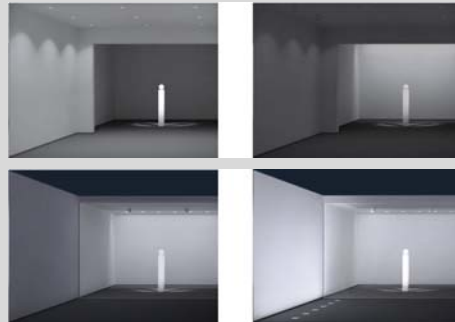


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Qualitative Lighting Design

- Ambient Lighting
- Depth and spatial perspective
 - Perception of boundary

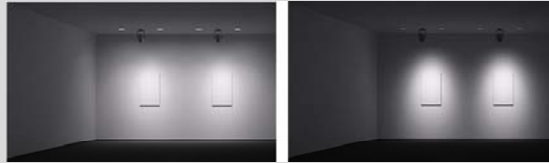


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Qualitative Lighting Design

- Accent Lighting
- Highlights / Ratios
- Information gathering

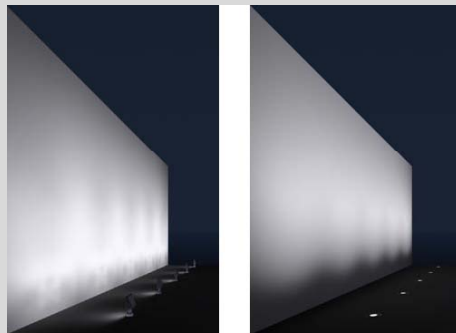


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Qualitative Lighting Design

- Task Lighting
- Illuminance / Luminance
- Orientation
- Environment

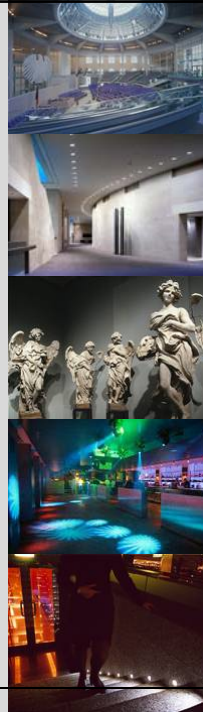


48410 – Acoustics and Lighting *Lighting Design – Dec 02 2004*

Qualitative Lighting Design

Types of Lighting

- General
 - Even Illumination
 - Direct / Indirect
 - Diffused / Aimed
- Wash Lighting
 - Object Orientated illumination
 - Highlight space proportion and limits
 - Symmetrical / Asymmetrical
- Accentuation
 - Emphasis elements
 - Points of interest
 - Hierarchical
- Projecting
 - Information
 - Effects
- Orientation
 - Adequate illumination
 - Routes
 - Signals



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