Quantity & Quality of lighting

Why to measure quantity & quality

- Insufficient lighting
  - To satisfy the objective of lighting
  - To improve visual performance
  - Impair the seeing process
  - Reduces the quantity and quality of work
- Excess lighting
  - Wastes energy
  - Increases cost of light (with respect to foot candles)

Quantity of Illuminance

- IES recommended lighting levels for mast tasks.
- Earlier for a particular category, a single value of lighting was mentioned.
- Present has three levels for each category based on
  - Age group
  - Speed and accuracy with which a visual task is performed.
  - Contrast level for different tasks.

Illuminance categories and Illuminance values

- Nine categories of visual tasks in order of ascending difficulty called as Illuminance Category (A to I).
- Three illuminance range in both footcandles and lux.
- Selection of recommended illuminance for a task
  - Determining illuminance category.
  - Applying weighting factors.

Lighting conditions

- Three lighting conditions are included:
  - general lighting throughout the room (A – C)
  - illumination on the task (D – E)
  - illumination on task, obtained by combining general and local (supplement) lighting (G – I)

General lighting

- A Use 30 lux for public areas with dark surroundings.
- B Use 75 lux for simple orientation for short temporary visits.
- C Use 150 lux for working spaces where visual tasks are only occasionally performed.

General lighting

- Adjustments to these values are made by selecting two weighting factors
  - Age of user is important (e.g. +40 years of age require more light)
  - Wall, floor and ceiling reflectance will vary, influencing the illumination

Weighting factors

- Select one of the following conditions and obtain factor.
- User age:
  - under 40 (factor -1)
  - 40-55 (factor 0)
  - over 55 (factor +1)
- Select one of the following conditions and obtain factor.
- Average room reflectance is:
  - over 70% (factor 1)
  - 30% to 70% (factor 0)
  - under 30% (factor+ 1)

Weighting factors

- Add the 2 factors algebraically for weight of influence.
- If total weight is (-1), 0, or (+1) use A, B and C values.
-
- If total weight is (-2) decrease A, B and C values by 1/3
- If total weight is (+2) increase A value by 2/3 and B and C values by 1/3

Illuminance category (A – C)

TYPE OF ACTIVITY	CATEGORY	RANGES OF ILLUMINANCES	
		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
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20

- Visual tasks are not difficult and not expected throughout the space.
- Eg. Walking through a corridor or lobby and also in work places where individual task lights are provided at specific locations

Illumination on the Task

- D Use 300 lx for performance of visual tasks of high contrast or large size
  - Eg. reading printed matter, typed originals, handwriting in ink, rough bench and machine work, ordinary inspection and rough assembly.
- E Use 750 lx for performance of visual tasks of medium contrast or small size
  - Eg. reading medium-pencil handwriting, and poorly printed or reproduced matter, medium bench and machine work, difficult inspection and medium assembly.
- F Use 1500 lx for performance of visual tasks of low contrast or very small size
  - Eg. reading handwriting in hard pencil on poor quality paper and very poorly reproduced matter, very difficult inspection.

Illumination on Task, Obtained by Combining General and Local Lighting

- G Use 3000 lx for performance of visual tasks of low contrast and very small size over a prolonged period
  - Eg. fine assembly, very difficult inspection, fine bench and machine work.
- H Use 7500 lx for performance of very prolonged and exacting visual tasks
  - Eg. most difficult inspection, extra fine assembly, bench and machine work.
- I Use 15000 lx for performance of very special visual tasks of extremely low contrast and small size.

Weighting factors

- User age
  - under 40 (factor -1)
  - 40-55 (factor 0)
  - over 55 (factor +1)
- Task background reflectance (e.g. a page)
  - over 75% (factor-1)
  - 30% to 70% (factor 0)
  - under 30% (factor +1)
- Speed and/or accuracy of task performance
  - not important (factor -1)
  - important (factor 0)
  - critical (factor +1).

Total Weighting factor

- Add the 3 factors algebraically for weight of influence.
  - If total weight is (-1), 0, or (+1) use D, E, F, G, H and I values.
  - If total weight is (-3) or (-2) decrease D, E, F, G, H and I values 1/3.
  - If total weight is (+2) or (+3) increase E, F, H and I values 1/3 and D, G, values 2/3.

Illuminance category (D – I)

TYPE OF ACTIVITY	CATEGORY	RANGES OF ILLUMINANCES	
		LUX	FOOTCANDLES
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
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 tasks	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

Example of illuminance categories for various activities or areas

- Dining - C
- Grooming, shaving, make-up - D
- Food preparation - E
- Serving and other non-critical tasks - D
- Laundry - D
- Ironing - D
- Reading books, magazines, newspapers - D
- Reading advanced piano scores - E

Example of illuminance categories for various activities or areas

- Reading advanced piano scores (substandard size) - F
- Reading simple piano scores - D
- Sewing Dark Fabrics (hand machine) - F
- Sewing medium fabrics (hand & machine) - E
- Sewing high contrast - D
- Study - E
- Table games - D
- General lighting for conversation, relaxation and entertainment - B
- General lighting for passage areas and for safety - B

Additional Illumination Adjustments

- A maximum lighting ratio of 5:1 is recommended when passing from one area to another for adaptation and psychological reasons.
- For example: a corridor next to an office with 750 lx should not have less than 150 lx.

Factors which affect the required quantity of illuminance

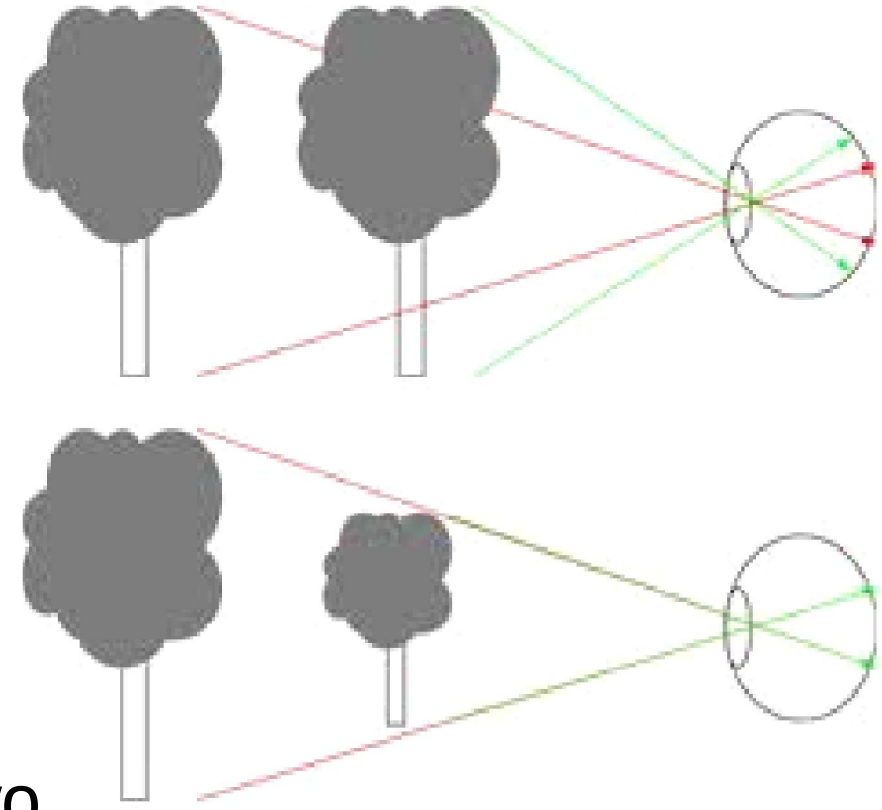
- Physiological factors
- Physical factors
  - Size
  - Brightness
  - Contrast
  - Time

Physiological factors

- Some common visual problems
  - Myopia – Near-sightedness
  - Hyperopia – Far-sightedness
  - Presbyopia – loss of focussing ability of the lens
  - Astigmatism - rays that propagate in two perpendicular planes have different foci
  - Yellowing of the lens
  - Clouding of the fluids in the interior of the eye
- Deterioration of the eye varies between individuals.
- Need for light increases by 2% or more per year after 20 years of age.
- So physiological factors are uncontrollable.

Physical factors

- Are controllable
- Size
  - Refers to visual size
  - Determines the ease with which the object may be seen
  - Influence the required illuminance
  - Eg. Two Balls placed at two different distances



Brightness

- Visual sensation produced by an object
- As the magnitude of visual sensation increases, the object is said to be brighter. i.e., makes easier to see.
- It is a function of both the reflectance of the object and illuminance.

Contrast

- Difference in luminance between the target object and its background.

Time

- Quantity of illumination required is related with time also.
- As the available time decreases the need for light increases.

Evaluation of Quantity of lighting

- Process
  - Meter readings are taken at various locations.
  - Evaluation of metered data.
  - Verification of data with design values.
- Photometers are used to measure the amount of light at a location.
- Otherwise called as Light meters.
- Selection of light meters is done by considering the following factors
  - Accuracy
  - Cosine correction
  - Colour correction
  - Suitability
  - Cost
  - Availability of repair and calibration service.

Light meters

Accuracy

- Absolute accuracy
  - Ability of the meter to measure a known standard.
  - Range from 3% to 15 %.
- Relative Accuracy
  - Ability of the meter to accurately reproduce the same reading when exposed to the same illuminance numerous times.
  - Ability to read differences in light levels.
  - 0.5% to 15%

Cosine correction

- When light strikes at any angle other than 90º, cosine law is applied to calculate illuminance.
- But to measure even at 90º, necessary correction has to be done called Cosine correction.
- For uniform lighting, need for cosine correction is not great. Eg. Office lighting
- For luminaires, good cosine correction is needed. Eg. Street and Parking lighting

Colour Correction

- Human eye does not respond equally to all colours.
- Light meters must be corrected to properly weight various colours so the meter indicates all illuminance which the eye can perceive.
- Colour correction is accomplished by inserting filters of various colours and densities so that colours have the correct weighting factors.

Suitability

- Depends on
  - Purpose of measurement
  - Location of measurement
  - Portability of meter
  - Simplicity or complexity of operation
  - Electrical requirements

Procedure for field photometry

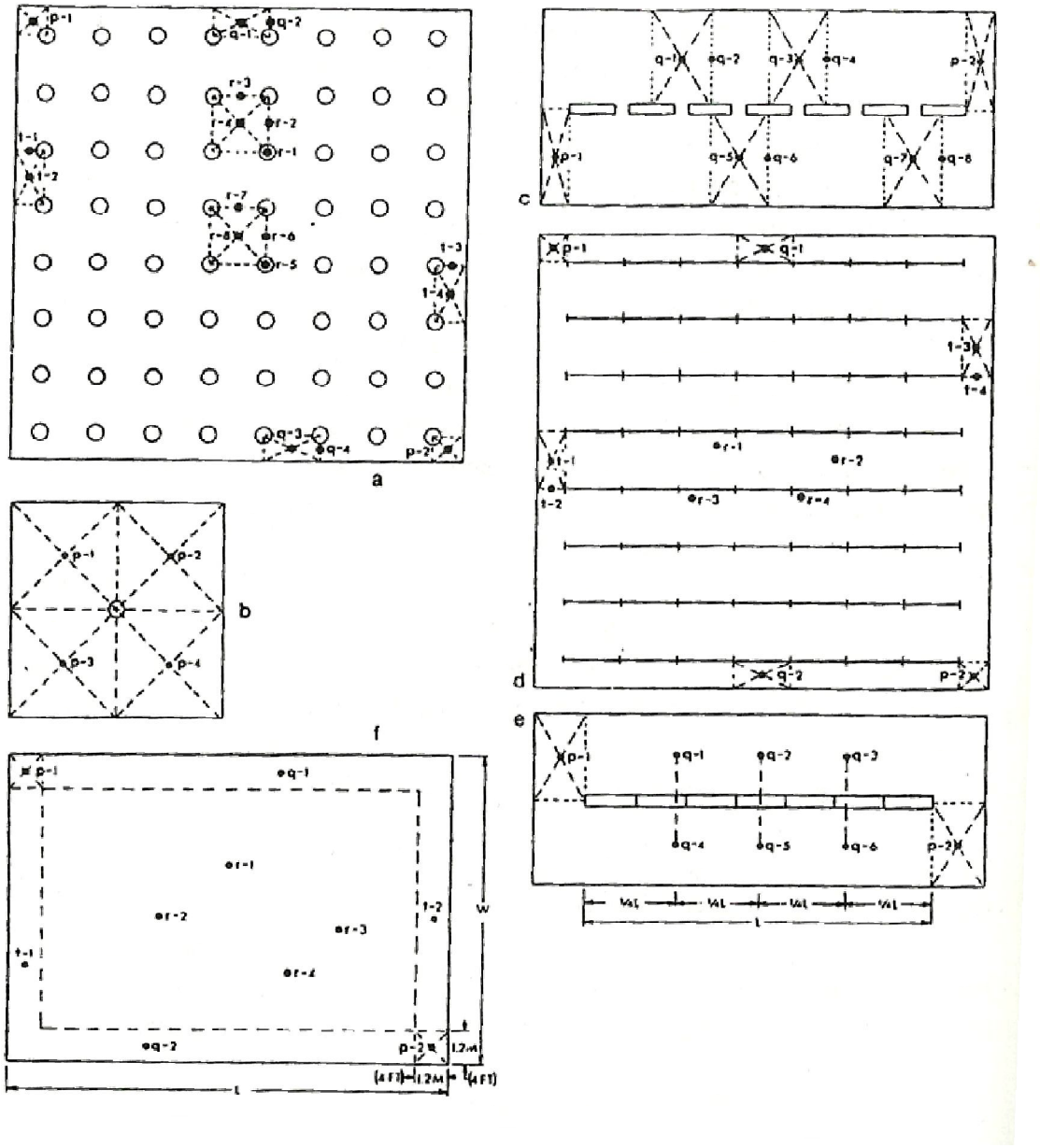
- To measure illuminance
  - Horizontal or Vertical
  - Reflectance or Luminance
  - At a point or average illuminance within a space.
- Process of measurement
  - Before any measurement, new lighting system must be burned in to destroy impurities and to stabilize them.
  - Operated for a minimum of one hour after they have been turned on.
  - The sensor of the meter should be uncapped and exposed to the light. Takes upto 15 minutes.

Interior measurement – Horizontal surface

- The sensor should be precisely placed at a location where the visual task is performed.
- Worker should be present in the normal work position because body shadow and light reflected from the worker must be included.
- Eg. Ordinary reading and office type tasks are normally performed in a horizontal plane.
- For average illuminance, the worker should be absent and illuminance is measure horizontally.
- The room is drawn on a grid pattern and readings are taken at the intersection of each horizontal and vertical grid line.
- These readings are then averaged.
- Accuracy improves as grid size decreases.

Measuring illuminance at work place

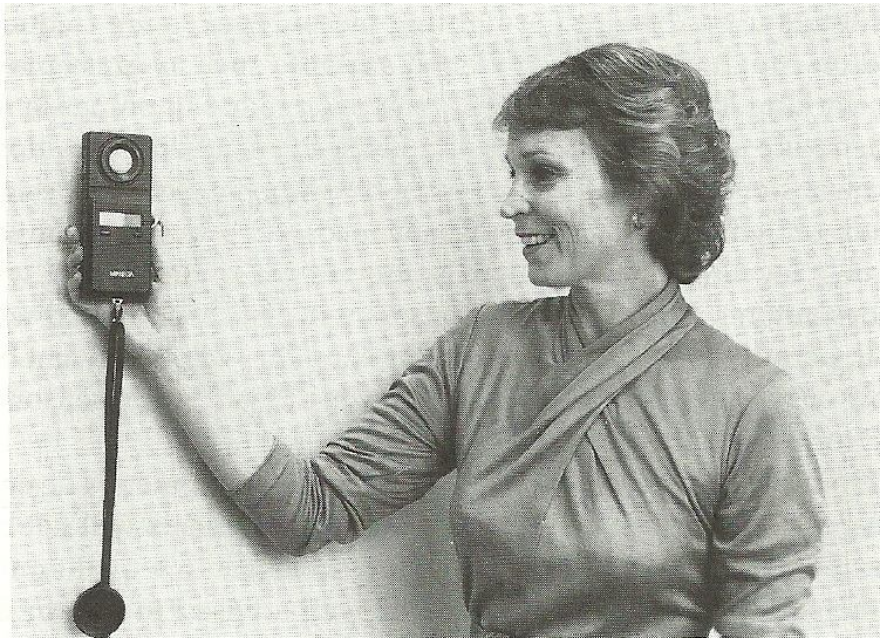
Location of measurement points



Interior measurement – Vertical surface

- Eg. Visual tasks like ware house racks, vertical merchandise displays.
- Care must be taken to avoid body shadow or reflected light which might distort the accuracy.
- Reflectance measurements
- Illuminance on the surface – placing meter on the wall with sensor facing outward.
- light reflected by the surface (luminance) – placing meter facing the wall at a distance of 12 to 18 inches.
- It is the ratio between the reflected reading to the incident reading.

Wall reflectance



Outdoor measurements

- Level of illumination is much lower than indoor levels. (0.1 to 10 footcandles)
- Illuminated outdoor areas may receive light from one or at the most two luminaires.
- Because of this meter must
  - Be designed to read low levels
  - Possess good cosine correction
- Since horizontal positions are rough, irregular or sloped surfaces, bubbles in a glimbal ring can be used to provide leveling.
- Sensors must also be equipped with long cables to move far away.

Quality of illumination

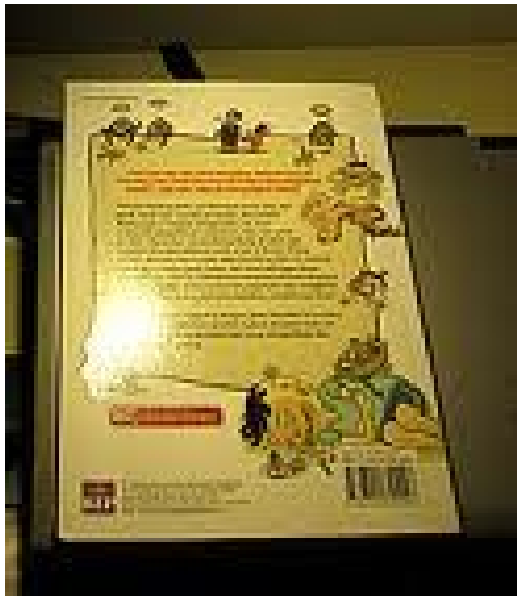
- Distribution of luminance within a visual environment.
- Two major components of quality are
  - Glare
  - Luminance ratio

Glare

- Sensation produced by luminance within the visual field that is sufficiently greater than the illuminance to which the eyes are adapted.
- Results in
  - Annoyance
  - Decreased productivity
  - Discomfort
  - Reduced visual effectiveness
- Types
  - Disability glare
  - Discomfort glare
  - Direct glare
  - Reflected glare

Disability glare

- Disability glare is glare that interfaces with visual performance.
- Eg. Glossy magazine page that makes the print unreadable.



Discomfort glare

- Discomfort glare is glare that produces visual discomfort.
- Eg. Bright head light while driving at night.

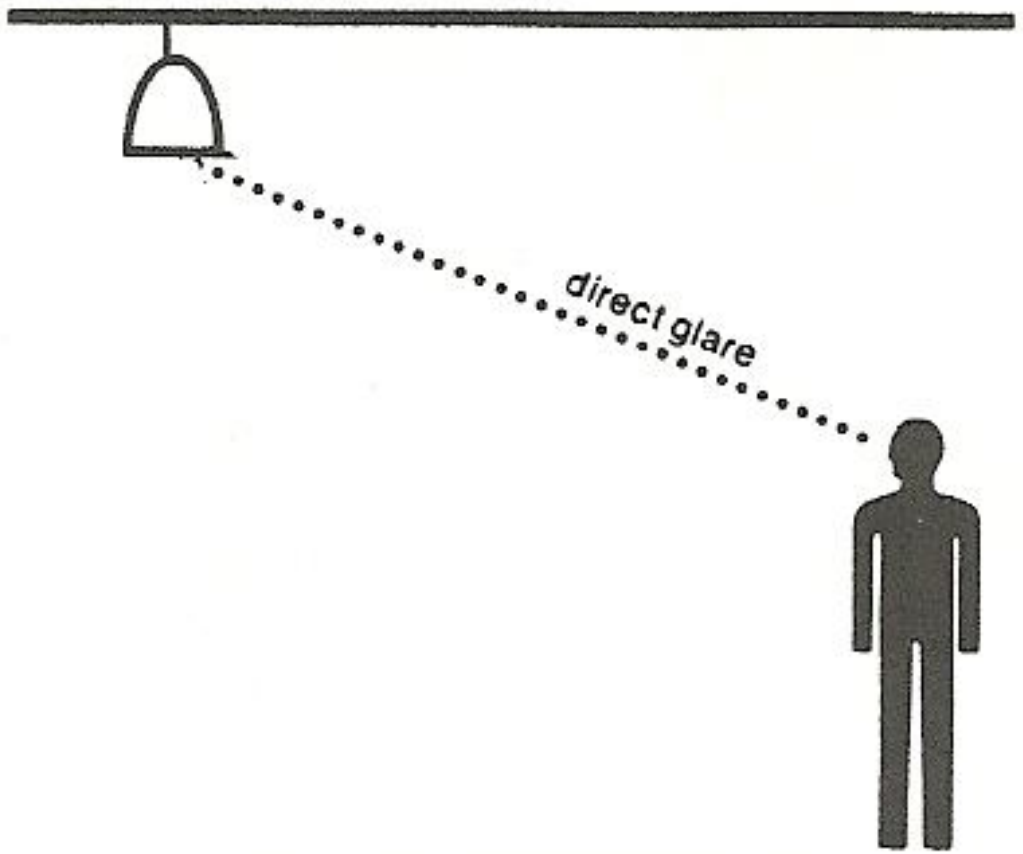
Direct Glare

- Caused by light which enters the eye directly from a bright light source even if the eye is not looking directly at the source.
- Caused by a bright light source located within the field of view.
- Due to
  - Bare incandescent lamps
  - Poorly designed fixtures
  - Improper placement of luminaire

Direct Glare

- Corrective measures
  - Remove the fixture from the filed of view
  - Reduce the luminance of the fixture. (lens, louver or shield)
  - Reduce the contrast between the fixture and the background. (bright and high reflectance paint in the background)

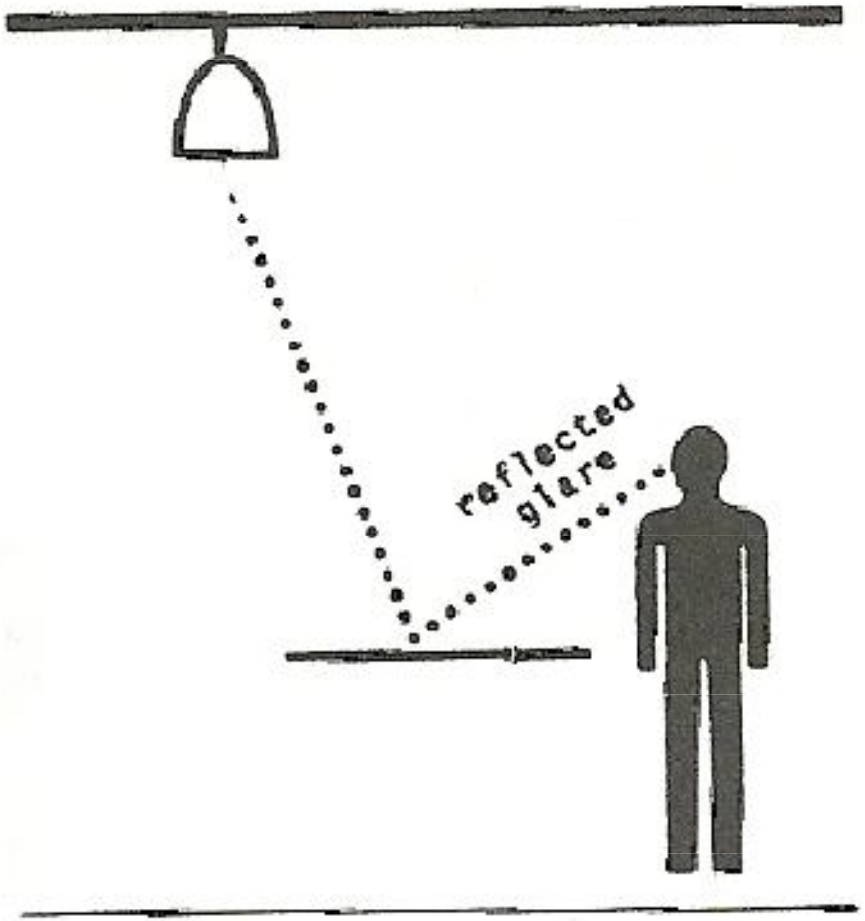
Direct Glare



Reflected Glare

- Result of reflection of the light source from a glossy or polished surface.
- Sometimes desirable
  - For some inspection tasks
  - To attract attention
- Corrective measures
  - Relocating the offending luminaire
  - Relocating the task or object
  - Moving the worker
  - Use of large–area low brightness light sources
  - Use of matte surfaces on floors, furniture and equipments

Reflected Glare

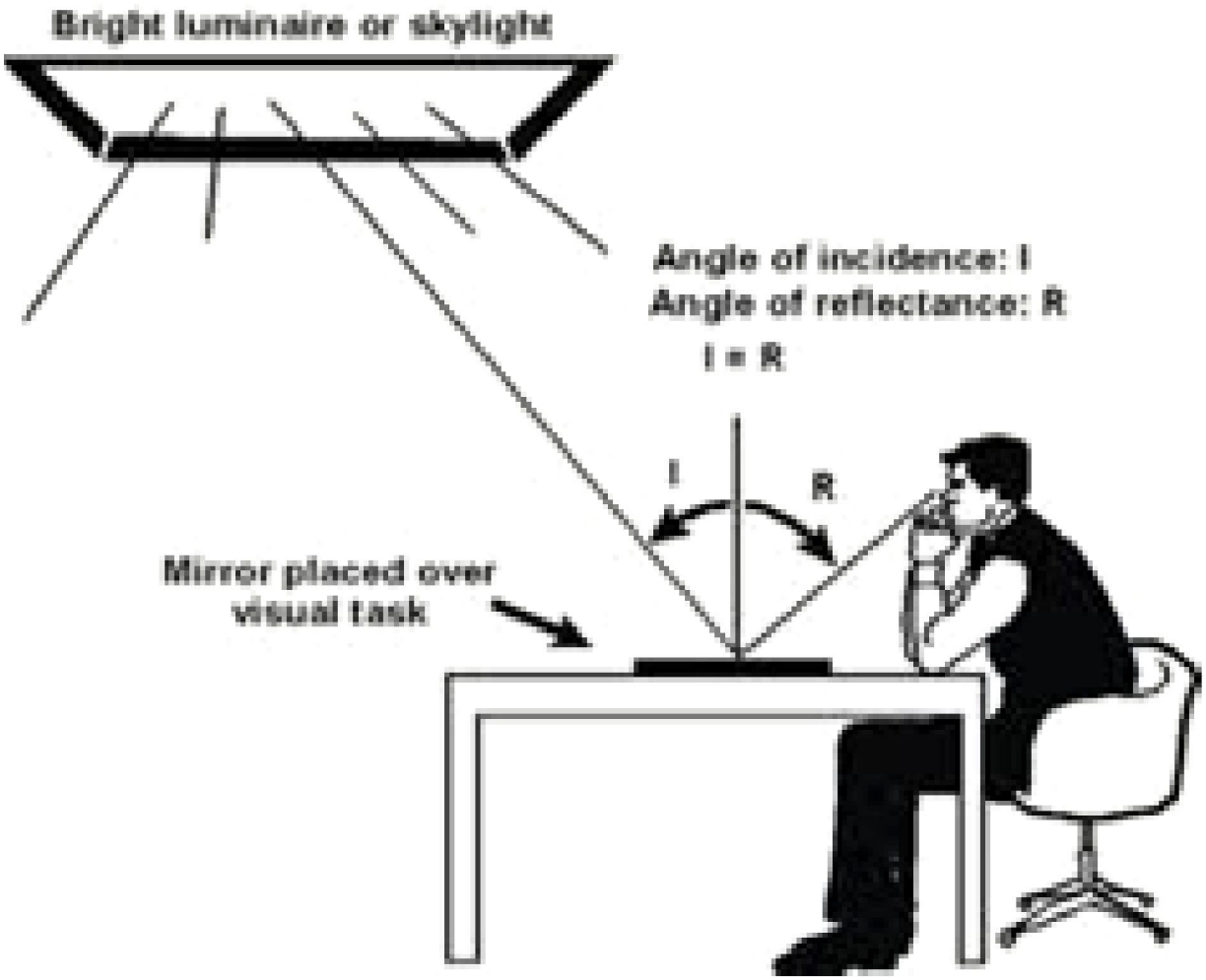


Veiling Reflections

- The reflection of a large luminous area on the surface being viewed.
- Caused by locating a luminaire directly above or slightly in front of the task.
- Very common in reading tasks in classrooms and offices.
- Fluorescent lamps and windows are common offenders.
- Corrective measures
  - Tilting or repositioning may be done to avoid this reflection.
  - Repositioning either the fixture or the task.
  - Fixtures should be positioned to the sides.
- A simple test is Mirror test.

Veiling Reflections

Mirror test


Bright luminaire or skylight
Angle of incidence: I
Angle of reflectance: R
I = R
I
R
Mirror placed over visual task