UNIT 4

Color and light: Color and the eye, Color consistency, Color terms, Reactions to color and color continuation, Color on engineering equipment's.

Temperature-Humidity-Illumination and Contrast: Use of Photometers, Recommended illumination levels, the ageing eye, Use of indirect (Reflected) lighting, Cost efficiency of illumination. Special purpose lighting for illumination and quality control

COLOR

Color is the visual perception based on the electromagnetic spectrum.

Though color is not an inherent property of matter, color perception is related to an object's light absorption, reflection, emission spectra and interference.

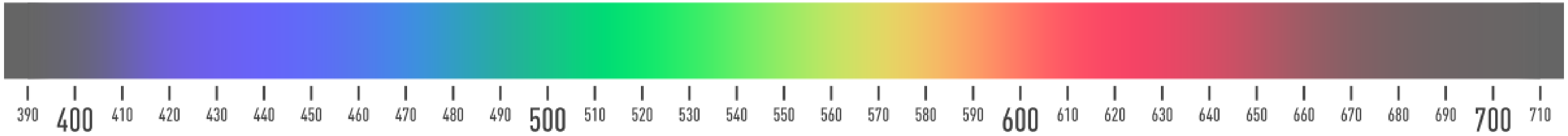
For most humans, color are perceived in the visible light spectrum with three types of cone cells (trichromacy).

Basic understanding of color

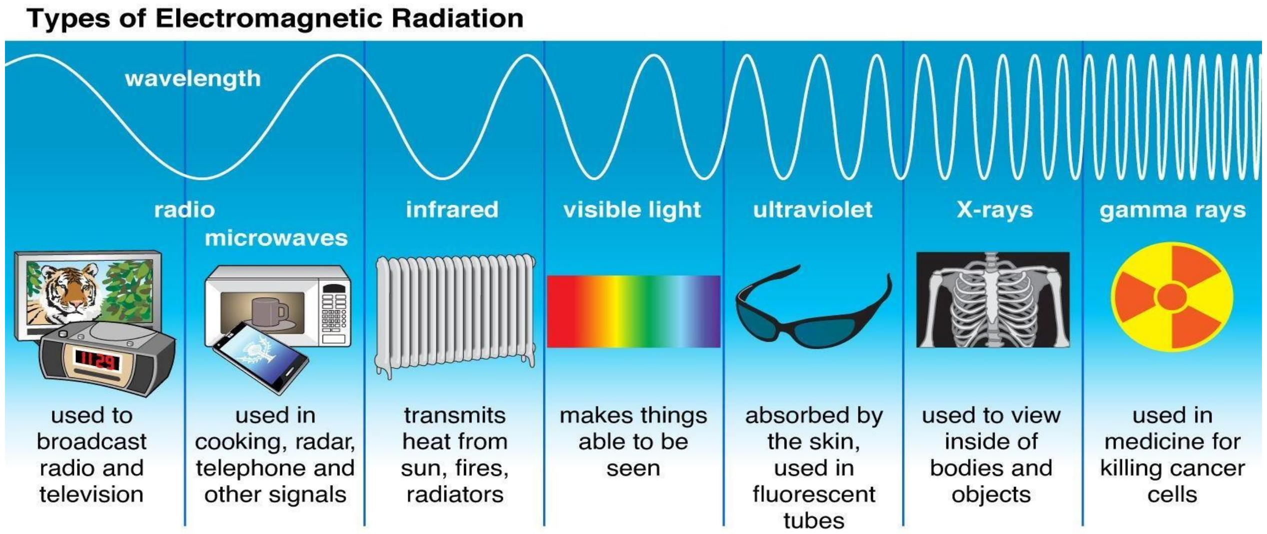
Cont..

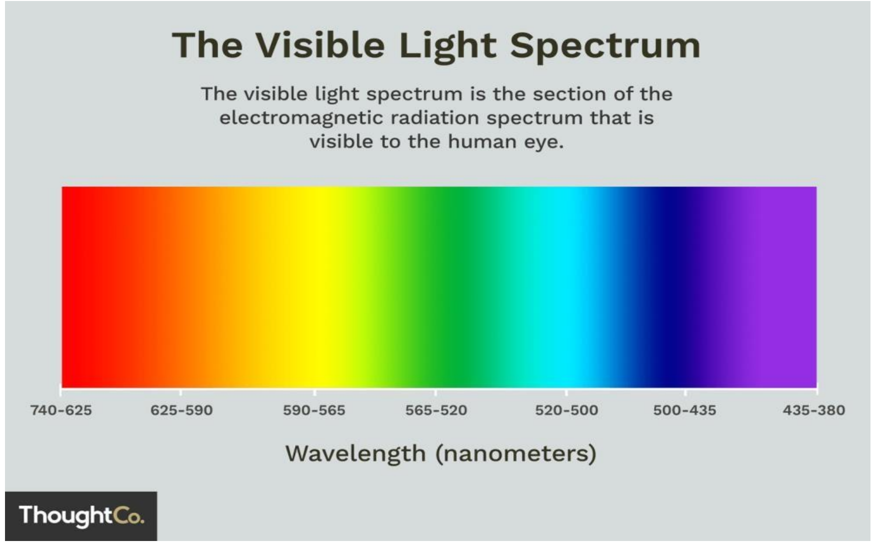
The visible spectrum perceived from 390 to 710 nm wavelength. Electromagnetic radiation is characterized by its wavelength (or frequency) and its intensity.

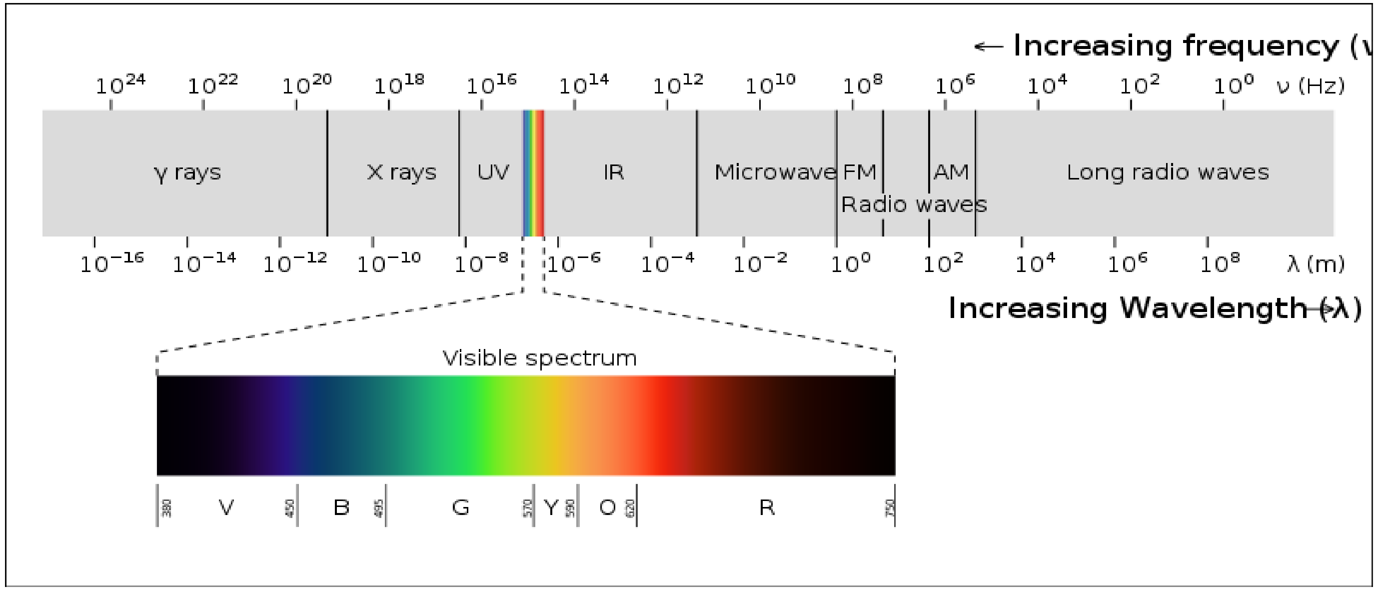
When the wavelength is within the visible spectrum (the range of wavelengths humans can perceive, approximately from 390 nm to 700 nm), it is known as "visible light".



The visible spectrum perceived from 390 to 710 nm wavelength

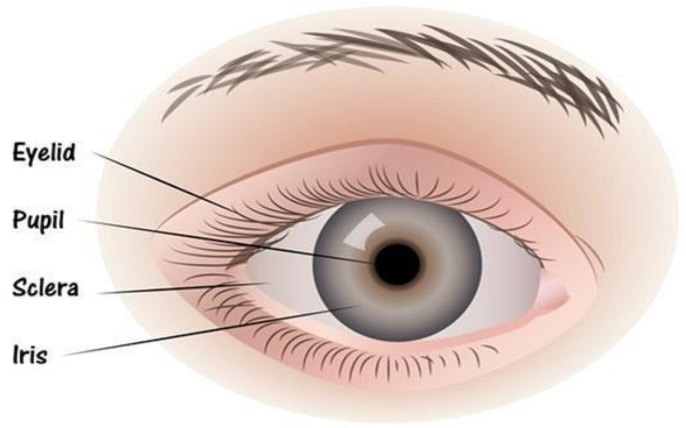

Types of Electromagnetic Radiation
wavelength
radio
microwaves
infrared
visible light
ultraviolet
X-rays
gamma rays
used to broadcast radio and television
used in cooking, radar, telephone and other signals
transmits heat from sun, fires, radiators
makes things able to be seen
absorbed by the skin, used in fluorescent tubes
used to view inside of bodies and objects
used in medicine for killing cancer cells

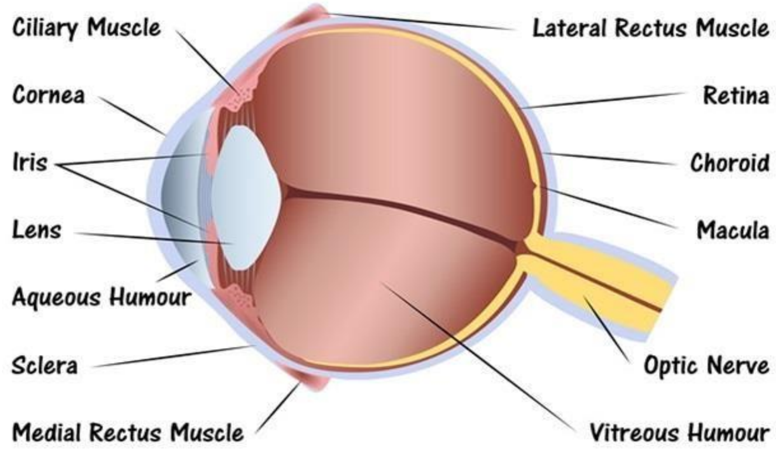

The Visible Light Spectrum
The visible light spectrum is the section of the electromagnetic radiation spectrum that is visible to the human eye.
740-625
625-590
590-565
565-520
520-500
500-435
435-380
Wavelength (nanometers)
ThoughtCo.


← Increasing frequency (ν
10^24 10^22 10^20 10^18 10^16 10^14 10^12 10^10 10^8 10^6 10^4 10^2 10^0 ν (Hz)
γ rays
X rays
UV
IR
Microwave
FM
AM
Radio waves
Long radio waves
10^−16 10^−14 10^−12 10^−10 10^−8 10^−6 10^−4 10^−2 10^0 10^2 10^4 10^6 10^8 λ (m)
Increasing Wavelength (λ) →
Visible spectrum
V
B
G
Y
O
R

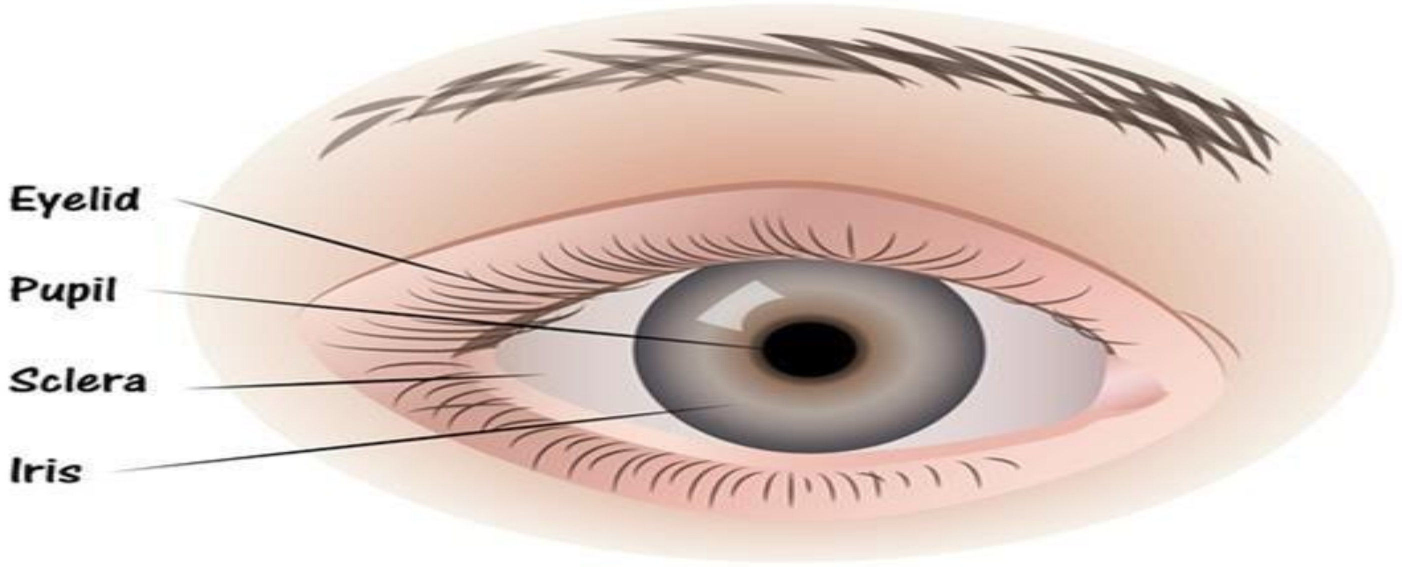
Human eye

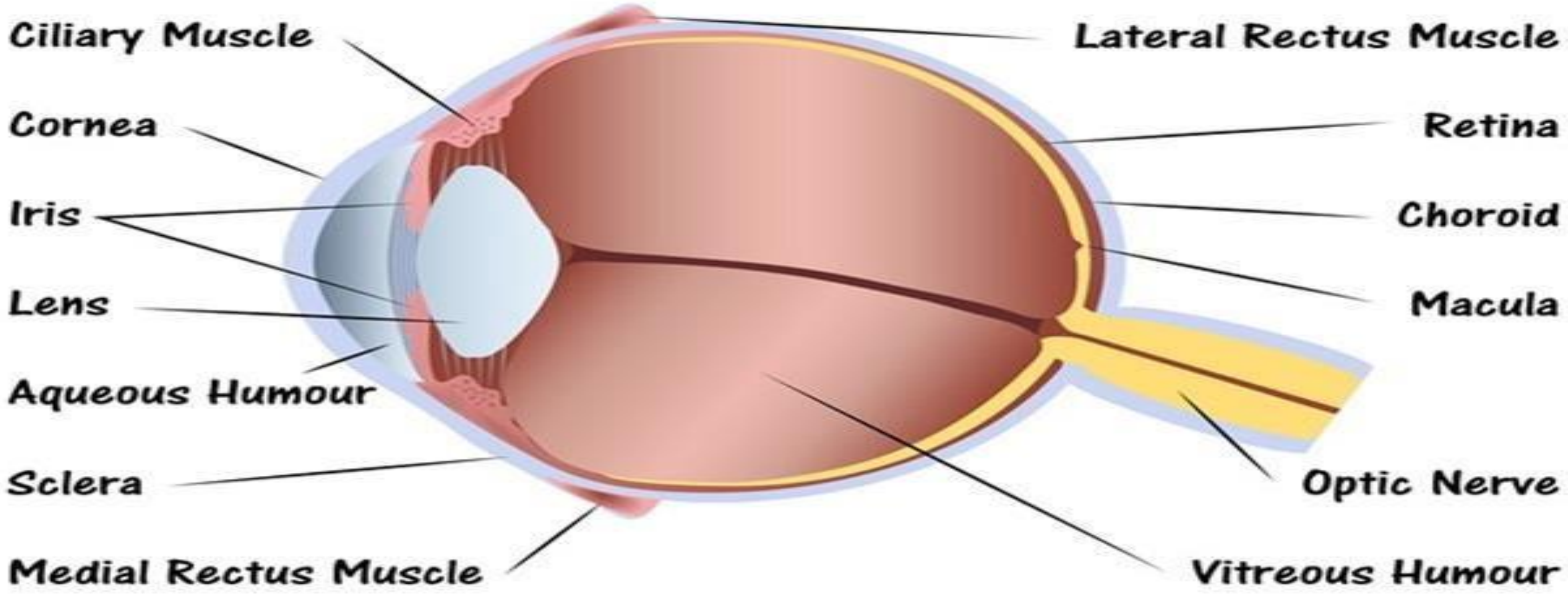
- The eye has several key structures that work together to facilitate vision. These structures include the cornea, lens, iris, pupil, retina, and optic nerve.
- The **cornea and lens** are responsible for focusing light onto the retina, which is located at the back of the eye.
- The **retina contains millions of photoreceptor cells** called rods and cones that are responsible for detecting light and transmitting visual information to the brain.





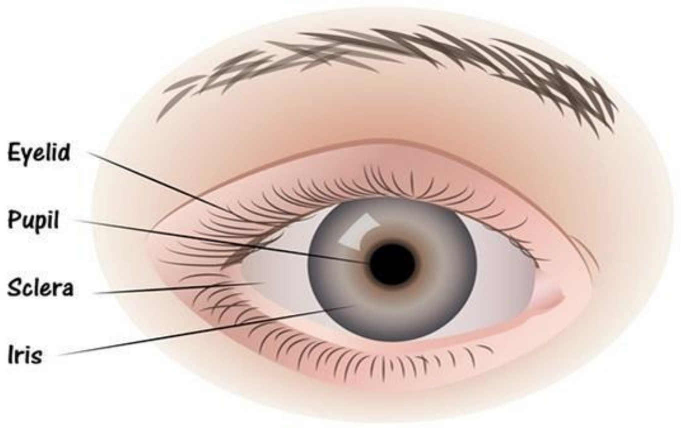
Human eye

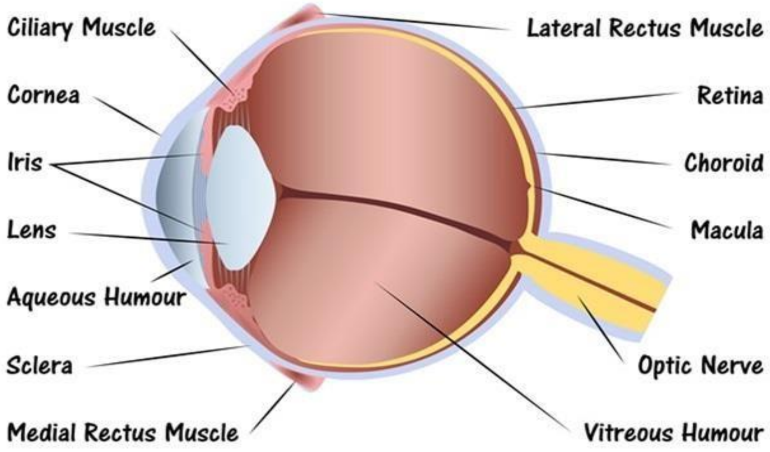

Eyelid
Pupil
Sclera
Iris


Ciliary Muscle
Cornea
Iris
Lens
Aqueous Humour
Sclera
Medial Rectus Muscle
Lateral Rectus Muscle
Retina
Choroid
Macula
Optic Nerve
Vitreous Humour

Cont..

- The **rods are more sensitive** to low levels of light and are responsible for vision in dimly lit environments, while the **cones are responsible for color vision** and function best in brighter light conditions.
- The iris controls the size of the pupil, which regulates the amount of light that enters the eye. **The optic nerve carries visual information** from the retina to the brain, where it is processed and interpreted as images.
- The eye also has several accessory structures that help protect and lubricate the eye, including the eyelids, eyelashes, and tear glands.





Color and the eye

- Color is a **perceptual experience** that arises from the **interaction between light, the eye, and the brain**.
- The human eye is a complex organ that is responsible for sensing light and transmitting information about the color and intensity of light to the brain.
- The eye contains three types of cone cells that are sensitive to different wavelengths of light

S.No	Cone cell type	Sensitive to colour
1	short-wavelength-sensitive (S) cones	Blue
2	medium-wavelength-sensitive (M) cones	Green
3	long-wavelength-sensitive (L) cones	Red

Cont..

- When **light enters** the eye, it is focused by the lens onto the retina, which contains millions of photoreceptor cells called rods and cones.
- The **rods are more sensitive** to low levels of light and are responsible for vision in dimly lit environments, while the cones are responsible for color vision and function best in brighter light conditions.
- When a **cone cell is stimulated by light**, it sends a signal to the brain that is interpreted as a **specific color.**
- The brain processes the signals from all of the cones and integrates them to create the perception of color. This process is called **color vision**, and it allows us to see a wide range of colors in our environment

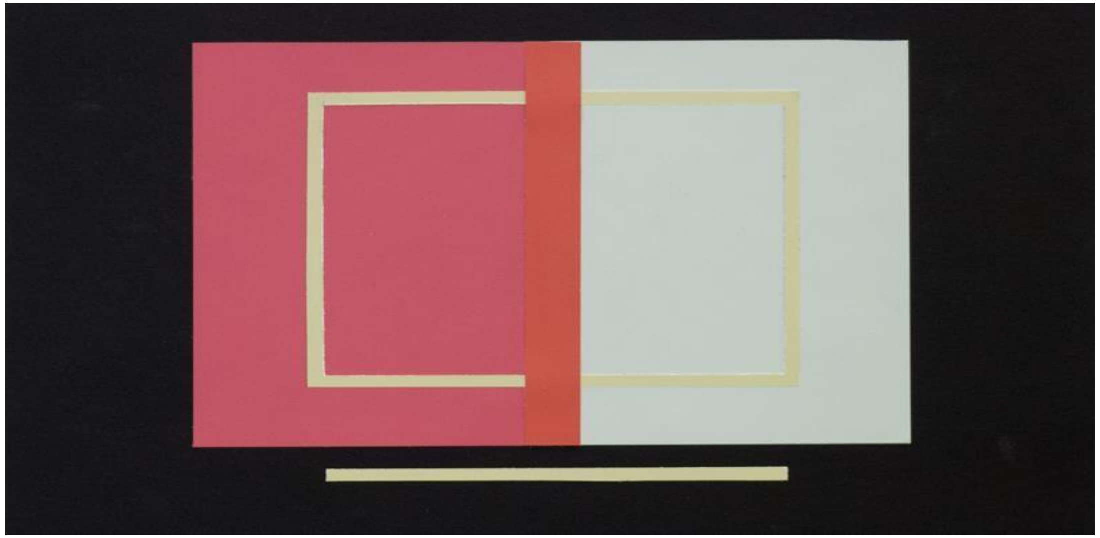
Color consistency in human eye

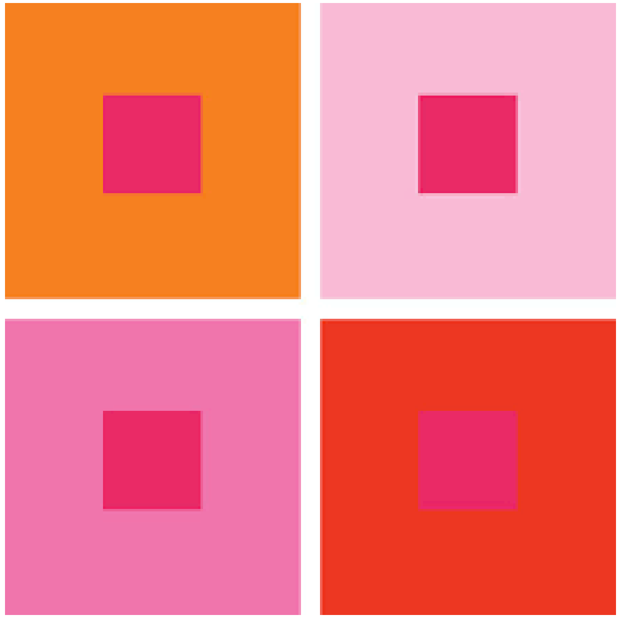
- **Color consistency** refers to the ability of the human eye and brain to perceive a consistent color appearance of an object despite variations in the illumination or surrounding colors
- The **human visual system** is able to adjust and compensate for changes in the illumination and color of an object in order to maintain a relatively stable perception of color.
- This is achieved through a process called **color consistency**, which involves the brain's ability to compare the spectral composition of light reflected by an object to the spectral composition of the light in the surrounding environment.
- By comparing the signals from different cones, the brain is able to infer the color of the object independent of the illumination or surrounding colors.
- For example, **a red apple** will still look **red** on a sunny day or cloudy day – or in a grocery store or a home.

Limitations of Color consistency

Color constancy is not perfect and can be influenced by factors such as

- the brightness of the surrounding environment
- the size and position of the object
- the duration of the exposure to the object
- changes in the illumination or color of an object may be too extreme for the visual system to compensate





- Due to the nature of the human eye and visual processing by the brain, there's an optical illusion that **the same color will look different depending on the background**

- It is known as the contrast effect,

Color

Color refer to the words or labels that are used to describe different colors

- Red
- Orange
- Yellow
- Green
- Blue
- Purple
- Pink
- Brown
- Gray
- Black
- White

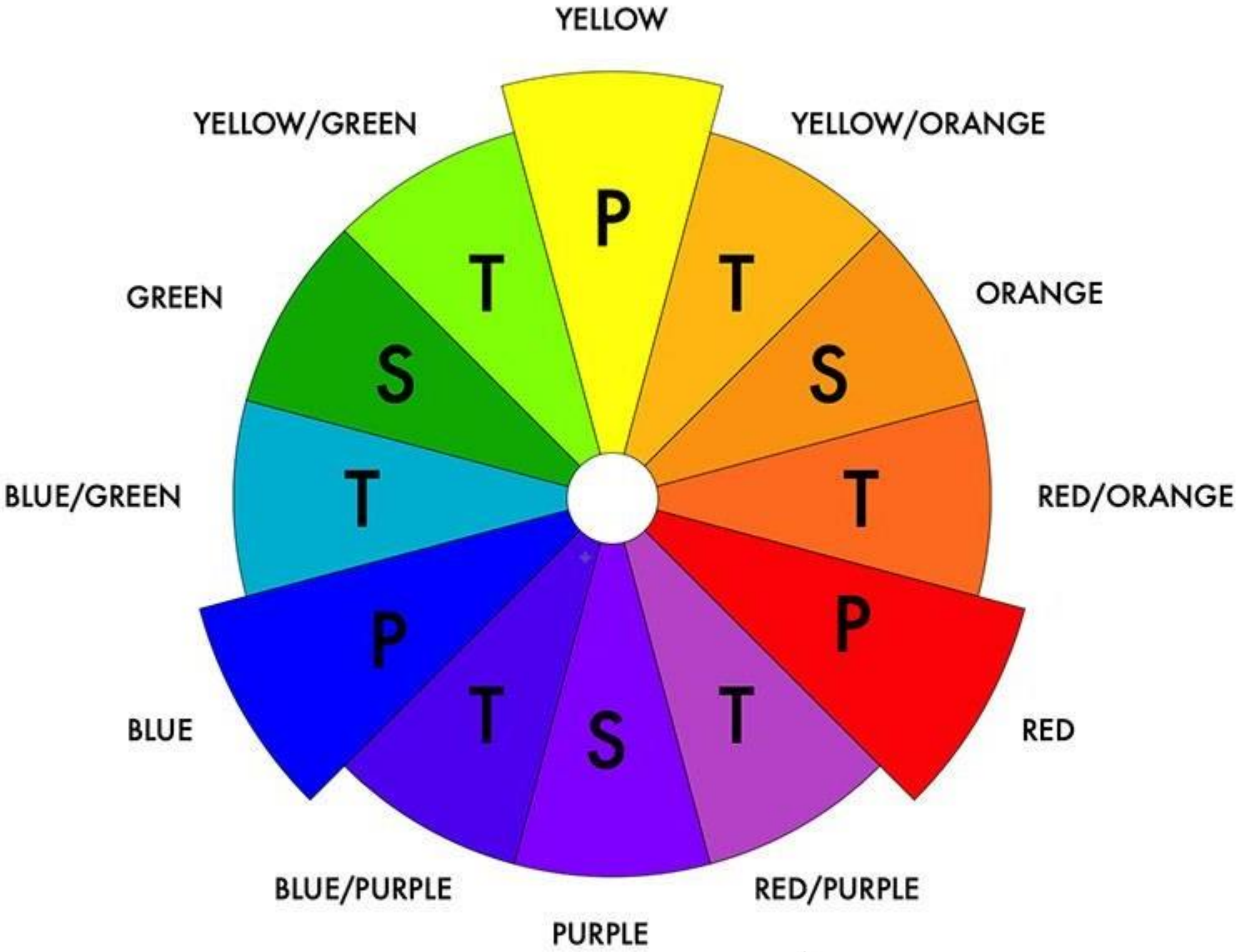
Yellow		Orange		Red		Pink		Violet	
Mellow yellow		Gold orange		Salmon red		Ruby pink		Mulberry violet	
Bumblebe yellow		Clay orange		Burgundy red		Hot pink		Hibiscus violet	
Eggnog yellow		Tiger orange		Redwood red		French rose		Plum violet	
Royal yellow		Honey orange		Raspberry red		Cerise pink		Grape violet	
Trombone yellow		Rust orange		Crimson red		Punch pink		Amethyst violet	
Tuscany yellow		Ochre orange		Indian red		Rose pink		Eggplant violet	
Mustard yellow		Amber orange		Sangria red		Lemonade pink		Orchid violet	
Laguna yellow		Fire orange		Imperial red		Magenta pink		Lollipop violet	
Peach yellow		Pumpkin orange		Barn red		Thulian pink		Lavender violet	
Flaxen yellow		Burnt orange		Maroon red		Fuchsla pink		Fandango violet	
Ecru yellow		Amber orange		Ferrari red		Brick pink		African violet	
Cream yellow		Goldenrod orange		Scarlet red		Ultra pink		Helio violet	
Sepia yellow		Apricot orange		Persian red		Amaranth pink		Mauve violet	
Cyber yellow		Cider orange		Carmine red		Bubble gum pink		Floral violet	
Flax yellow		Spice orange		Mahogany red		Flamingo pink		Orchid violet	

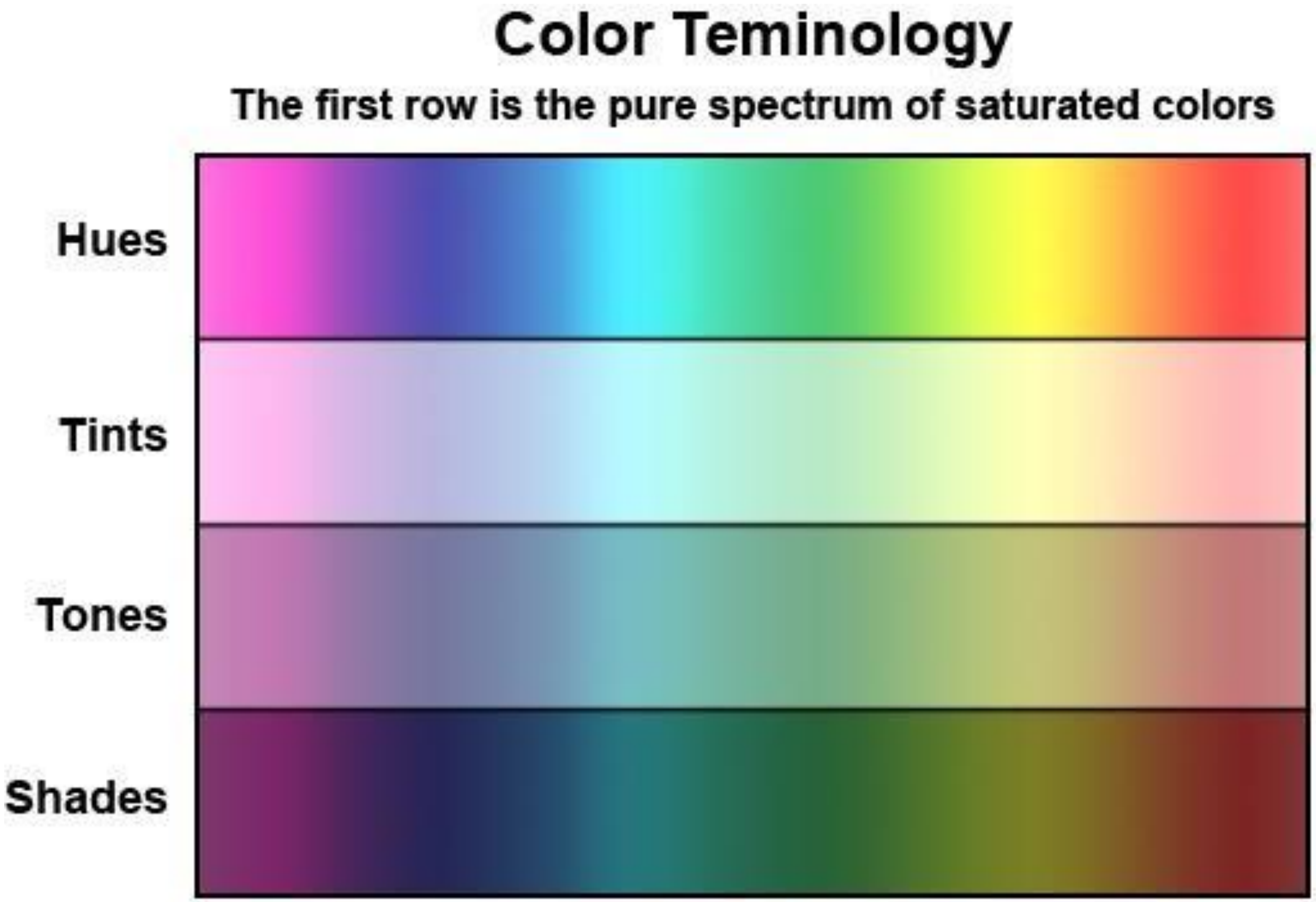
Color wheel

P- Primary Color

S- Secondary Color

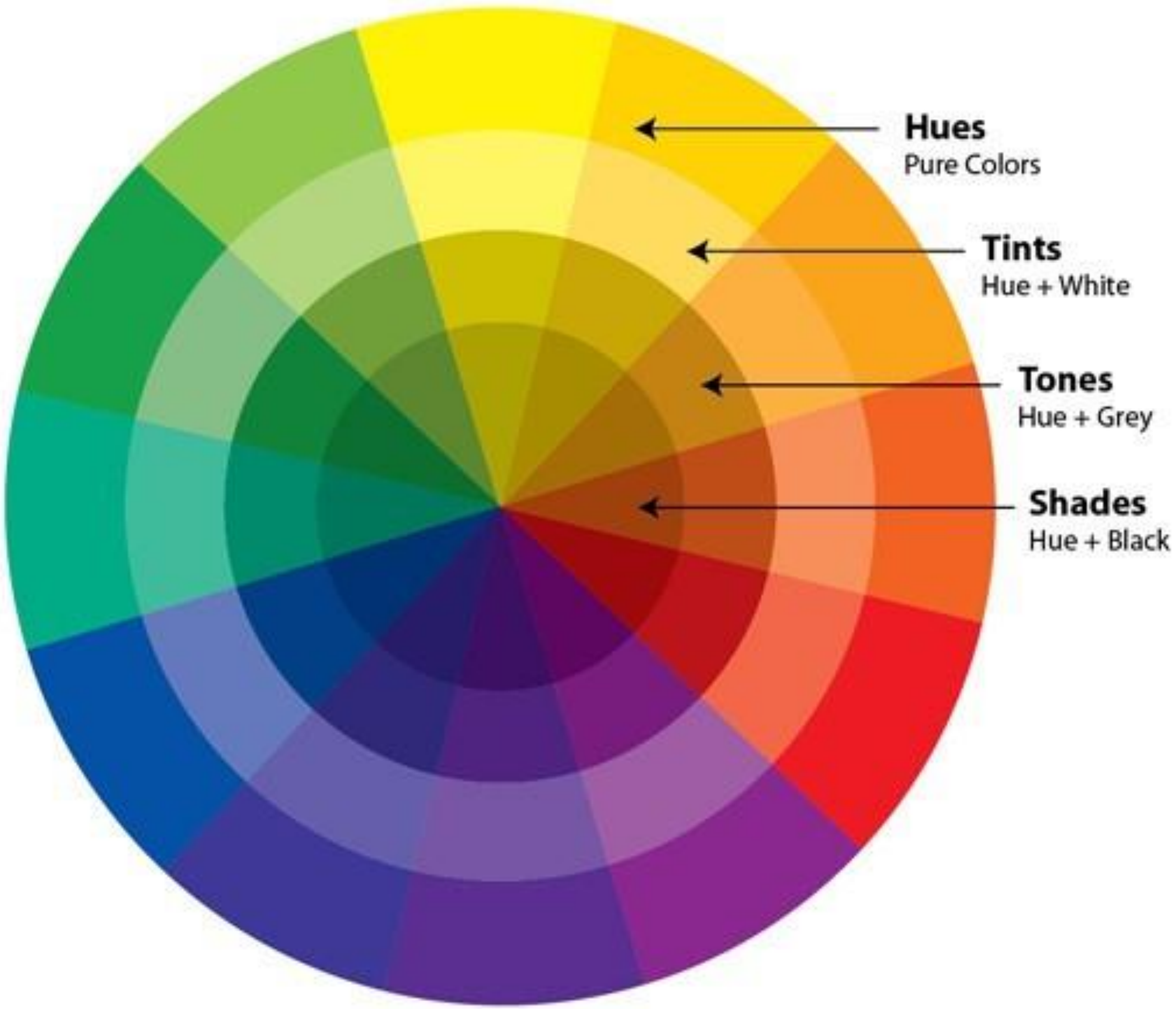
T- Tertiary Color





- A tint is a color with **white** added to it
- A tone is color with **gray** added to it
- A shade is color with **black** added to it

Difference Between Hue, Chroma, Tint, Tone, and Shade



Color terms

Some of the color terms commonly used in ergonomics include:

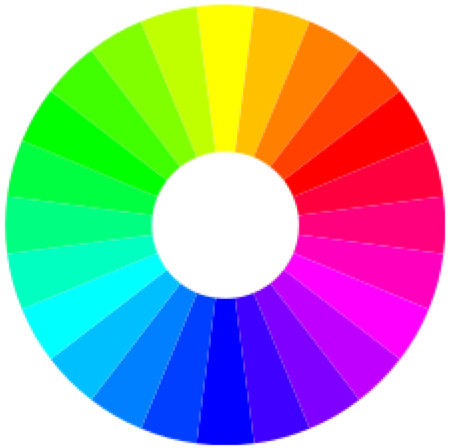
Contrast:

Contrast refers to the difference in color, brightness, or texture between two adjacent surfaces. High contrast can be useful for enhancing visibility and reducing the risk of errors or accidents, while low contrast can be difficult to distinguish and may increase the risk of errors or accidents.

Cont..

- **Hue:**

Hue refers to the **color of an object or surface**, such as red, green, or blue. Hue can have important implications for the perception of products and environments, and can be used to create a specific mood or aesthetic

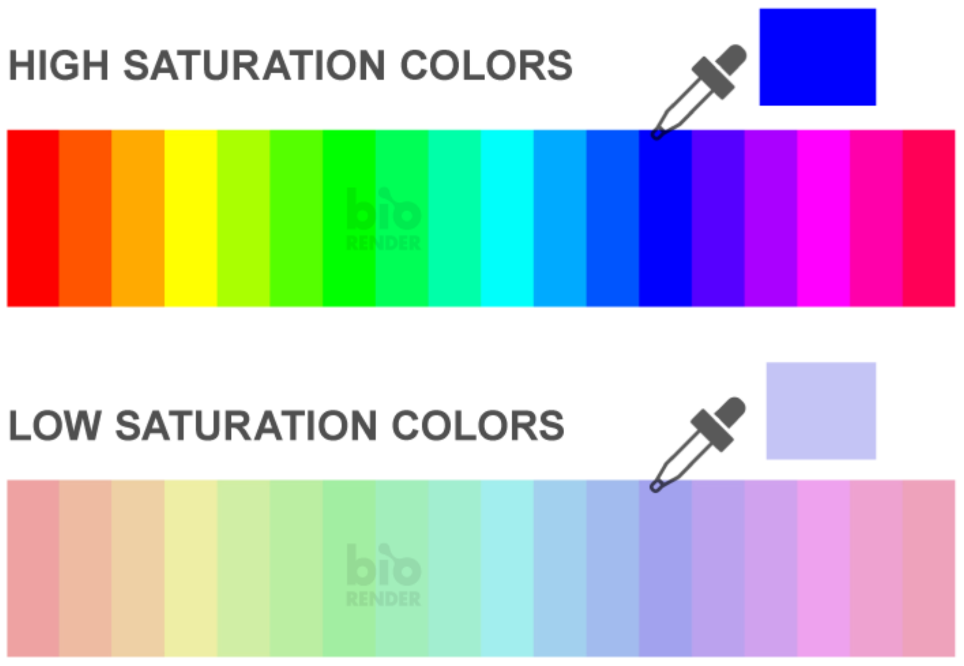


Hue 24 color

Cont..

Saturation:

Saturation refers to the **intensity or purity of a color**, and can influence the perceived brightness and clarity of an object or surface. High saturation can be attention-grabbing and energizing, while low saturation can be calming and soothing

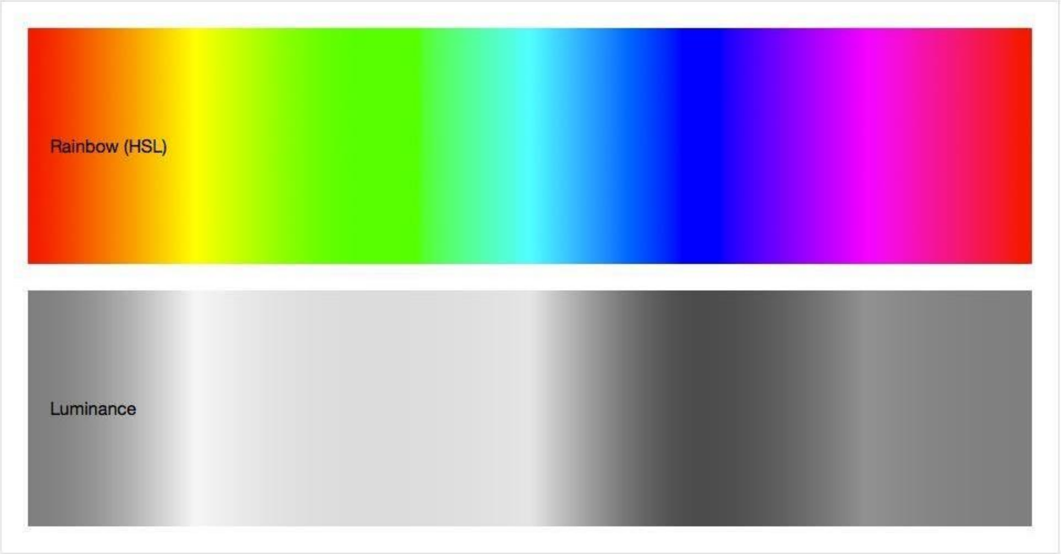


Cont..

Luminance:

Luminance refers to the **brightness of an object or surface**, and can have important implications for visual comfort and performance. **High luminance** can cause glare and visual discomfort, while **low luminance** can reduce visibility and increase the risk of errors or accidents

Rainbow Luminance



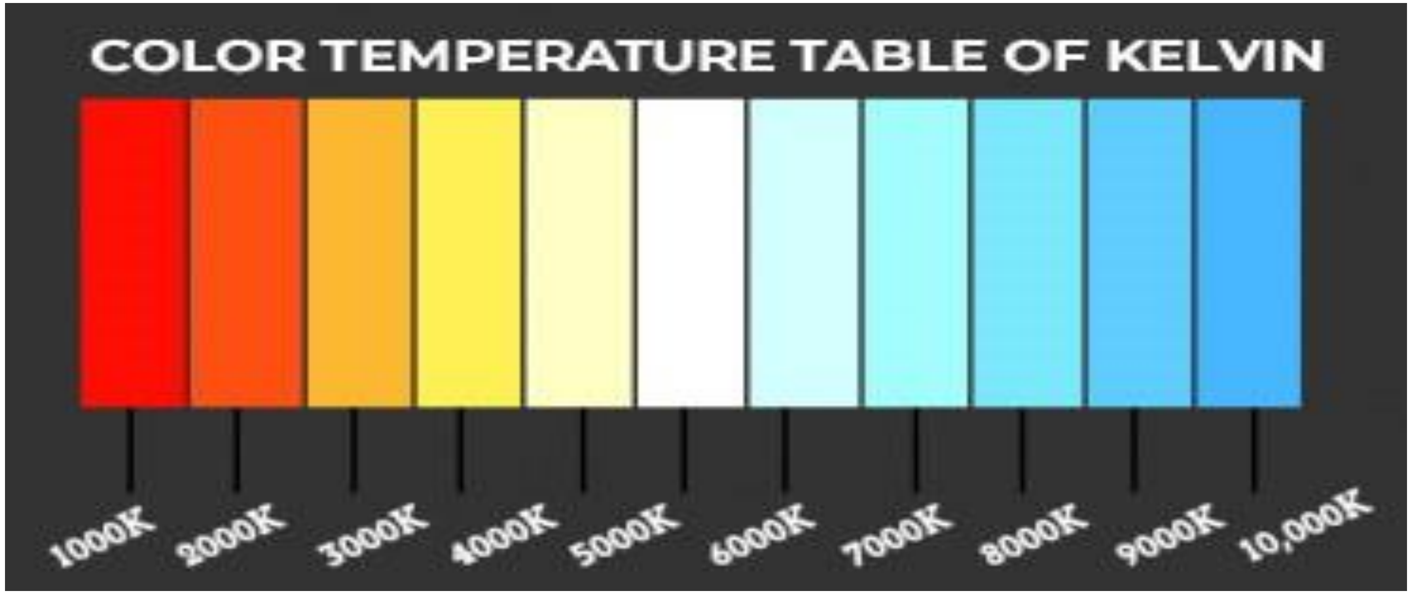
The HSL rainbow (all hues at 100% saturation and 50% lightness) has highly variable luminance: we perceive some parts of the rainbow, such as between yellow and cyan, as significantly brighter than other parts of the rainbow. This, along with a lack of perceptual uniformity, makes the rainbow color scale unsuitable for visualization. Use the Lab or HCL color space instead.

Open in a new window.

Cont..

Color temperature:

Color temperature refers to the warmth or coolness of a color, and can influence the perceived comfort and suitability of products and environments. Warm colors (such as red or yellow) can be energizing and inviting, while cool colors (such as blue or green) can be calming and soothing.



Reactions to color

- Humans react to the surrounding colors and the colors effect the psychological mood of the humans

Red: often associated with **passion, excitement, and danger**. It can also symbolize love, anger, and power.

Blue: often associated with calmness, trust, and intelligence. It can also symbolize sadness and depression.

Green: often associated with nature, growth, and harmony. It can also symbolize envy and greed.

Yellow: often associated with happiness, optimism, and energy. It can also symbolize caution and cowardice.

Cont..

Purple: often associated with royalty, luxury, and creativity. It can also symbolize mystery and magic.

Orange: often associated with enthusiasm, warmth, and playfulness. It can also symbolize aggression and flamboyance.

Black: often associated with sophistication, power, and mystery. It can also symbolize death and evil.

White: often associated with purity, innocence, and simplicity. It can also symbolize emptiness and coldness.

- Colors are viewed with different angle by different cultures and personal associations

Color continuation

- Color continuation is a design technique that involves continuing a color from one element of a design to another, creating a sense of unity and coherence.
- This technique can be used in a variety of design applications, such as graphic design, interior design, fashion design, and more.
- Color continuation can also be used to create emphasis and draw attention to certain elements of a design

Color continuity gone wrong

- This is not design continuity, but could rather be described as painful monotony

Color on engineering equipment's.

The Standard Color-Code System:

- RED - Denotes fire safety equipment and safety containers for flammables. Identifies emergency devices (emergency shut-off switches, stop bar, buttons).

- ORANGE - Be aware of machinery or equipment that can cut, crush, shock or cause other injury

- YELLOW - Cautions against physical dangers (slipping, tripping, falling, caught- between and striking-against hazards).

Cont..

- GREEN - Locates first-aid equipment.

- BLUE - Cautions against the use or movement of equipment being repaired or the starting of equipment.

- MAGENTA AND YELLOW or BLACK AND YELLOW - Warns of radiation hazards.

- BLACK, WHITE OR A COMBINATION - Controls and designates traffic movement, marks aisle, housekeeping areas and similar areas.

Colour coding on safety helmets

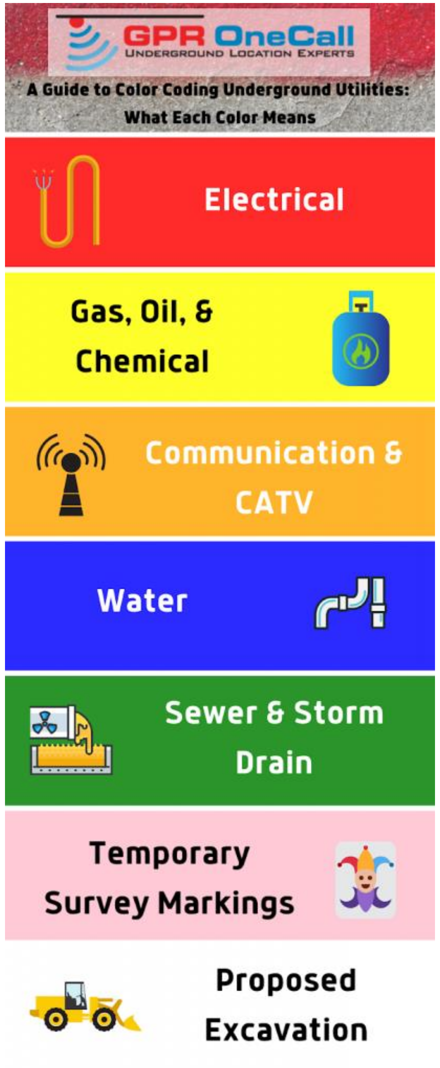
Industrial Floor marking colours

YELLOW	Traffic lanes, machines guards, walkways and work cells. etc
ORANGE	Materials and product inspection, Operation, storage locations. etc
GREEN	Materials and components finished goods, Safety equipment .etc
RED	Defects, fire, scrap, rework and red tag areas, unused items .etc
BLUE	Equipment, Inventory, Machines lines, Inspection points, raw materials .etc
WHITE	Equipment and fixtures, Process materials, Repair tools, clean lines.etc
BLACK	Work in progress, Materials and components, work in progress, raw materials .etc
GRAY	Floorstand displays, racks, storage, warehouse .etc
BLACK/ YELLOW	Flammable or combustive material containers, extra caution working area, . etc
BLACK/ WHITE	Areas to be clarified for operational purposes, not related to safety/compliance standards. etc

Color coding on heavy equipment for excavations

COLOR CODE IDENTIFIERS

WHITE	Proposed Excavation
PINK	Temporary Survey Markings
RED	Electric Power Lines, Cables, Conduit, and Lighting Cables
YELLOW	Gas, Oil, Steam, Petroleum, or Gaseous Materials
ORANGE	Communication, Alarm or Signal Line, Cables, or Conduit
BLUE	Potable Water
PURPLE	Reclaimed Water, Irrigation, and Slurry Lines
GREEN	Sewers and Drain Lines



Color coding in piping

Basic identification colours		
Pipe Contents Name Reference	Colour	Colour
Water	Green	
Steam	Silver-Grey	
Oils (mineral, vegetable or animal) Combustible liquids	Brown	
Gases in either gas or liquid phase - except air	Yellow Ochre	
Acids / Alkalis	Violet	
Air	Light Blue	
Waste effluents	Black	
Electrical Services & Ventilation Ducts	Orange	
Safety Colour		
Safety Reference	Colour	Colour
Fire	Red	
Water from a public supply	Auxiliary blue	
Water from any other source	Flint grey	
Warning	Yellow	

COLOR OF CYLINDER

GAS	USA	INTERNATIONAL
oxygen	Green	White
Carbon dioxide	Gray	Gray
Nitrous oxide	Blue	Blue
helium	Brown	Brown
Nitrogen	Black	Black
air	Yellow	White & black

What is Light

- To the optical engineer, Light is simply a very small part of the electromagnetic spectrum, sandwiched between ultraviolet and infrared radiation.

- The visible portion of the **electromagnetic spectrum** extends from about 380 to about 780 nanometers. Radiation in this region is absorbed by the photo receptors of the human visual system and there by initiates the process of seeing.

- The Illuminating Engineering Society of North America (IESNA) defines light as "**radiant energy that is capable of exciting the retina and producing a visual sensation**".

- Light, therefore, cannot be separately described in terms of radiant energy or of visual sensation, **but is a combination of two**.

Use of Photometers

- A photometer is a device that is used to measure light. The root word "photo," means light.

- A photometer is a device that measures the strength of electromagnetic radiation in the range of infrared radiation to ultraviolet radiation, including the visible part of the electromagnetic spectrum.

- Usually, a photometer converts light into electric current by using a photoresistor, photomultiplier, and photodiode.

Cont..

- Photometry is the science of **measuring visible light** which the human eye perceives. The measuring unit of illuminance is the LUX or foot-candle. In other words, it indicates the amount of illumination a specific surface unit receives.

Photometers measure the following parameters:

- Illuminance
- Light absorption
- Irradiance
- Reflection of light
- Scattering of light
- Fluorescence
- Luminescence
- Phosphorescene

Cont..

Applications of Photometry:

- Luminance meters come in use for various businesses. For instance, to test the brightness of the display, instrument boards, night-vision gadgets, light sources, and so on.

- Precise and exceptionally touchy photometers also come in use to quantify the different proportions of cathode-beam tubes, fluid precious stone presentations, and other flat board displays.

- Various parameters of Light like illuminance, Irradiation, Scattering and Reflection of Light, Fluorescence, etc are measured using Photometers.

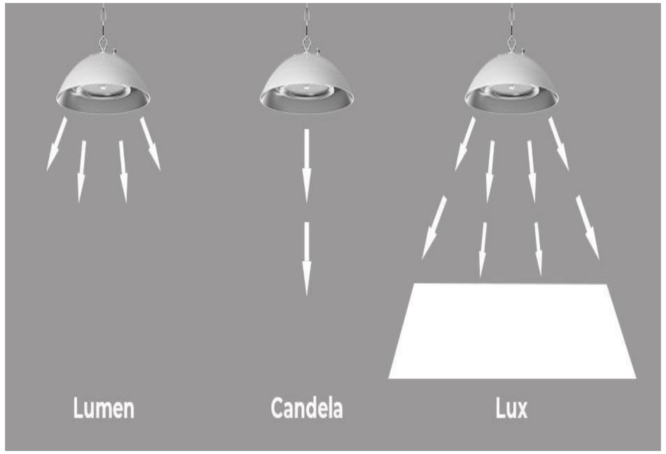
Luminance meters

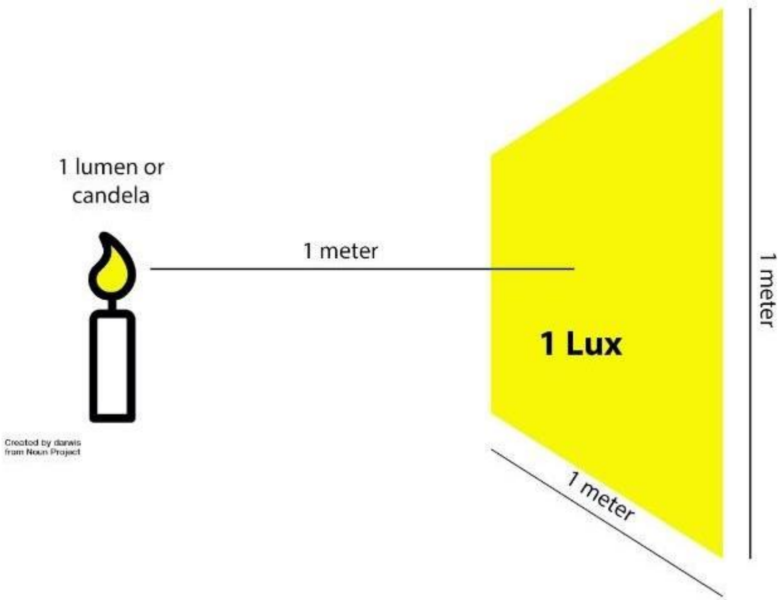
Units of Measurement of Light

Light is typically measured using different units depending on the application. Here are some common units of measurement for light:

Candela (cd): measures the intensity of a light source in a specific direction. It is used to measure the brightness of a light source, such as a flashlight or headlight.

Lumen (lm): measures the total amount of visible light emitted by a light source in all directions. It is used to measure the brightness of a light bulb or other light source.





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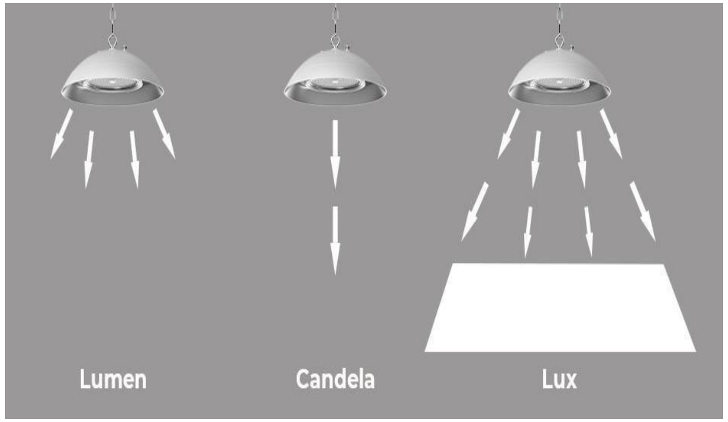
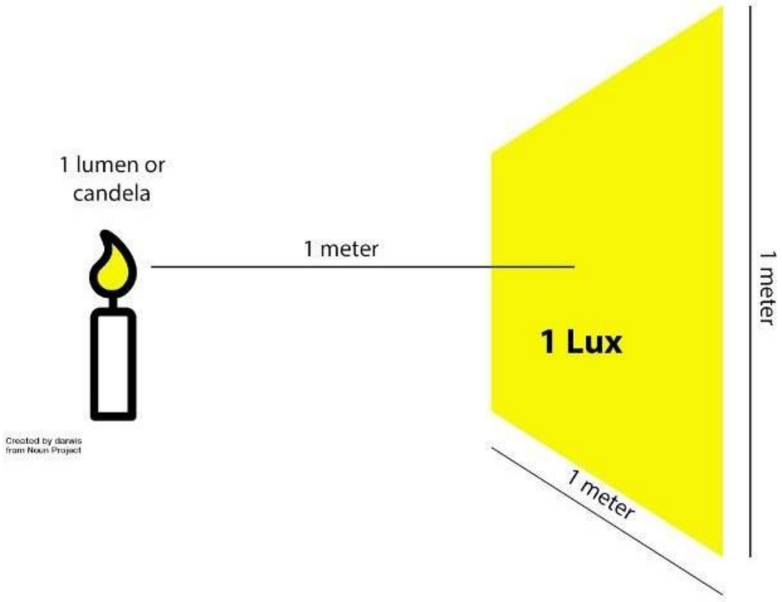
Lux (lx): measures the amount of light that falls on a surface per unit area. It is used to measure the illumination of a space or object.



Foot-candle (fc): measures the amount of light that falls on a surface per unit area, with one foot-candle equal to one lumen per square foot.

It is commonly used in the United States to measure lighting levels in indoor spaces.



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Measuring Units Light Level - Illuminance

Illuminance is measured in *foot candles (ftcd, fc, fcd)* in the Imperial system or *lux* in the metric SI system.

- *one foot candle = one lumen* of *light density per square foot*
- *one lux = one lumen per square meter*
- *1 lux = 1 lumen / sq metre = 0.0001 phot = 0.0929 foot candle (ftcd, fcd)*
- *1 phot = 1 lumen / sq centimetre = 10000 lumens / sq metre = 10000 lux*
- *1 foot candle (ftcd, fcd) = 1 lumen / sq ft = 10.752 lux*

Cont..

Outdoor Light Levels:

Common outdoor light levels at day and night:

Condition	Illumination	
	(ftcd)	*(lux)*
Sunlight	10000	107527
Full Daylight	1000	10752
Overcast Day	100	1075
Very Dark Day	10	107
Twilight	1	10.8
Deep Twilight	0.1	1.08
Full Moon	0.01	0.108
Quarter Moon	0.001	0.0108
Starlight	0.0001	0.0011
Overcast Night	0.00001	0.0001

Cont..

Indoor Light Levels

- The outdoor light level is approximately *10000 lux* on a clear day. In a building in the area **closest to the windows** the light level may be reduced to approximately *1000 lux*. In the middle area it may be as low as *25 - 50 lux*. Additional lighting is often necessary to compensate low levels.
- According *EN 12464 Light and lighting - Lighting of workplaces -Indoor work places*, the minimum illuminance is 50 lx for walls and 30 lx for ceilings. Earlier it was common with light levels in the range *100 - 300 lux* for normal activities.
- Today the light level is more common in the range *500 - 1000 lux* - depending on activity. For precision and detailed works the light level may even approach *1500 - 2000 lux*.

Lumens and lighting facts label

Lumens:
Lumens measure how much light you are getting from a bulb. More lumens means it's a brighter light; fewer lumens means it's a dimmer light.

The brightness, or lumen levels, of the lights in your home may vary widely, so here's a **rule of thumb:**

- To replace a 100 watt (W) incandescent bulb, look for a bulb that gives you *about* 1600 lumens. If you want something dimmer, go for fewer lumens; if you prefer brighter light, look for more lumens.
- Replace a 75W bulb with an energy-saving bulb that gives you about 1100 lumens
- Replace a 60W bulb with an energy-saving bulb that gives you about 800 lumens
- Replace a 40W bulb with an energy-saving bulb that gives you about 450 lumens.

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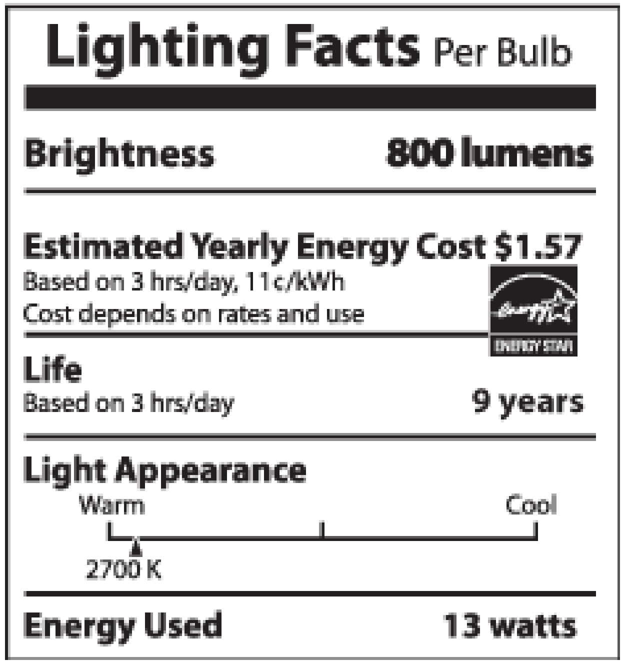
Lighting Facts Label:

To help consumers, the Federal Trade Commission requires manufacturers to include a product label for light bulbs on the package. It helps people buy the light bulbs that are right for them.



Like the helpful nutrition label on food products, the Lighting Facts label helps consumers understand what they are really purchasing. The label includes the following information:

- Brightness, measured in lumens
- Estimated yearly energy cost (similar to the Energy Guide label)
- Lifespan
- Light appearance, measured by correlated color temperature (CCT) on the Kelvin (K) scale, from warm to cool.

Artificial Light sources

Minimum light output (lumens)	Electrical power consumption (watts)			
	Incandescent		Compact fluorescent	LED
	Non-halogen	Halogen		
90	15	6	2–3	1–2
200	25		3–5	3
450	40	29	9–11	5–8
800	60		13–15	8–12
1,100	75	53	18–20	10–16
1,600	100	72	24–28	14–17
2,400	150		30–52	24–30[10]
3,100	200		49–75	32[11]
4,000	300		75–100	40.5[12]

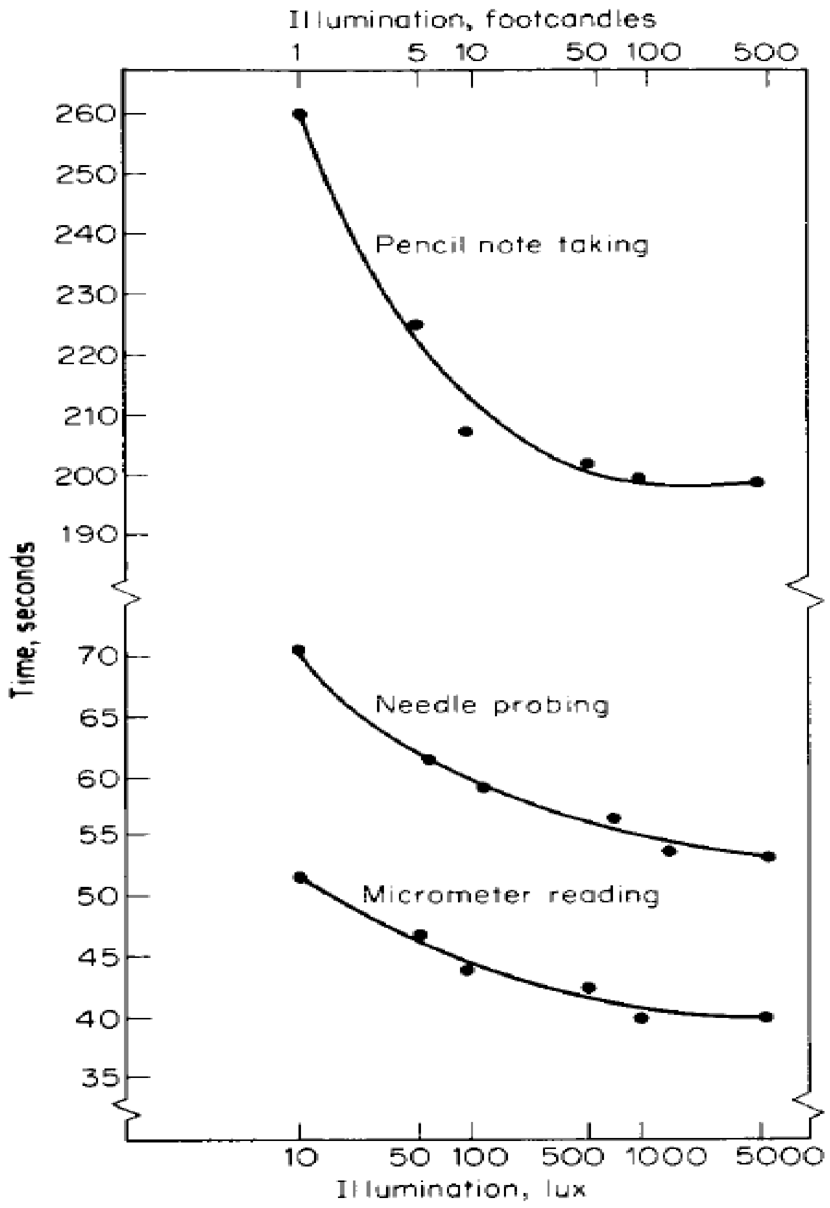
Effect of light on performance

- The **graph clearly indicates** that the increase in the illumination helps in reducing the task completion time in 3 different scenarios

- So it is evident that proper lighting conditions effect the performance of the workers

- From the graph it is also observed there is no appreciable increase in productivity after 1000lux

Type of work	German DIN	IES
Precise assembly work	1000 lx	3000 lx
Very precise machine tool work	1000	7500
General office work	500	750



Recommended illumination levels

Appropriate lighting levels are important for safety, comfort and energy efficiency. The level of light on a surface is called illuminance. It is expressed as lumens per square metre or lux.

In determining the appropriate amount of lighting, consider:

- the passive design day lighting provided by the design of the building
- direct lighting from lamps
- reflected light – levels will be higher from lighter-coloured or glossier surfaces.

Cont…

Good lighting design is said to be lighting that ‘allows you to see what you need to see quickly and easily and does not cause visual discomfort but does raise the human spirit’.

Insufficient light levels can be uncomfortable and unsafe. Too much light can cause glare, which is also uncomfortable and can cause headaches or eyestrain, and too much artificial lighting wastes energy.

Recommended lighting levels are:

- 150–200 lux for general household activity – for example, vacuuming or washing.
- 300–500 lux for focused activity – for example, reading or studying, working on a car.
- 800-1000 lux or more for concentrated activity – for example, fine detail sewing.

Recommended light levels for different types of work spaces are indicated below:

Activity	Illumination (lux, lumen/m^2)
Public areas with dark surroundings	20 - 50
Simple orientation for short visits	50 - 100
Working areas where visual tasks are only occasionally performed	100 - 150
Warehouses, Homes, Theaters, Archives	150
Easy Office Work, Classes	250
Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories	500
Supermarkets, Mechanical Workshops, Office Landscapes	750
Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres	1,000
Detailed Drawing Work, Very Detailed Mechanical Works	1500 - 2000
Performance of visual tasks of low contrast and very small size for prolonged periods of time	2000 - 5000
Performance of very prolonged and exacting visual tasks	5000 - 10000
Performance of very special visual tasks of extremely low contrast and small size	10000 - 20000

Minimum lighting recommendations

Activity	Typical locations/ types of work	Average illuminance (lux) 1x	Minimum measured illuminance (lux) 1x
Movement of people, machines and vehicles[a]	Lorry park, corridors, circulation routes	20	5
Movement of people, machines and vehicles in hazardous areas; rough work not requiring any perception of detail	Construction site clearance, excavation and soil work, loading bays, bottling and canning plant	50	20
Work requiring limited perception of detail[b]	Kitchens, factories assembling large components, potteries	100	50
Work requiring perception of detail[c]	Offices, sheet metal work, bookbinding	200	100
Work requiring perception of fine detail[d]	Drawing offices, factories assembling electronic components, textile production	500	200

Minimum lighting recommendations

Table for exclusion zone angles

Lamp type	Angle for exclusion zone	Comments
Tubular fluorescent lamps	10 degrees	This is for viewing the lamps from the side; viewing the lamps end-on does not require any control
Discharge lamps with a fluorescent coating; incandescent lamps wth frosted glass	20 degrees	
Discharge and incandescent lamps which allow a direct view of the arc tube or the filament	30 degrees	

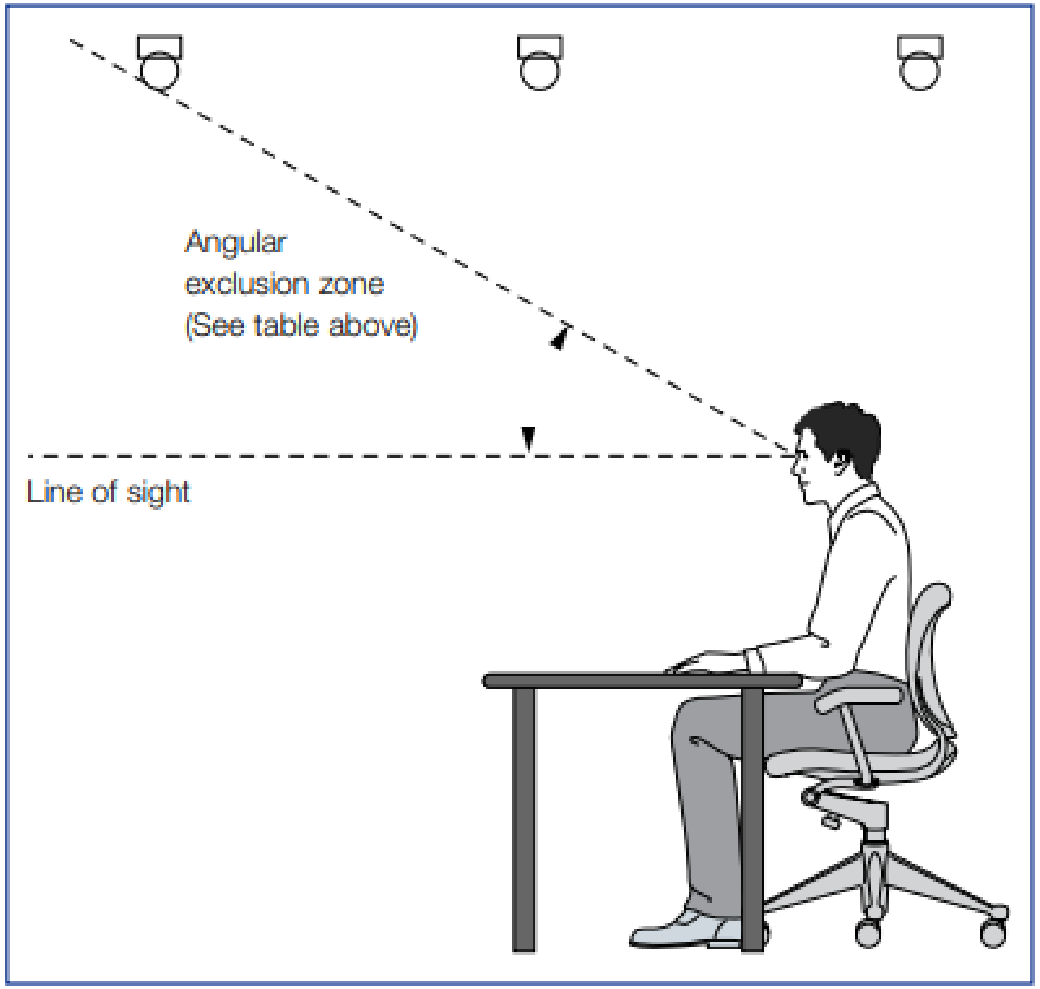


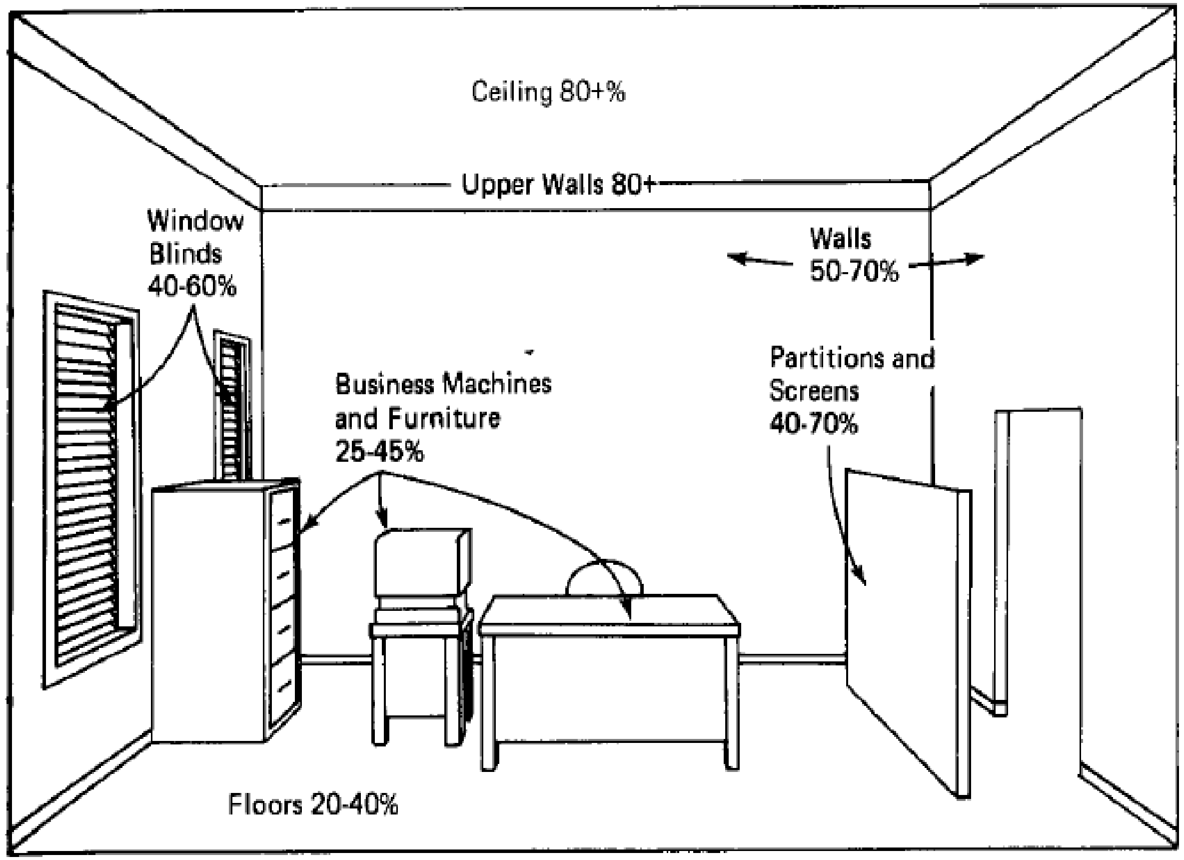
Figure 18 Angular zone from which bare lamps should be excluded to control discomfort and disability

Light Reflectance

- The **distribution of light** is influenced by the **reflectance of** walls, ceiling, and other room surfaces.

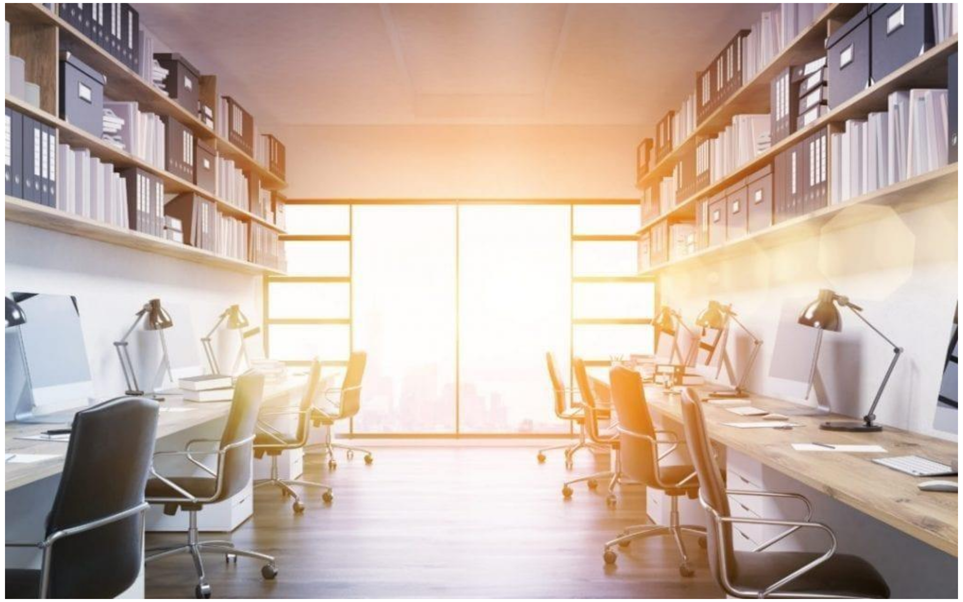
- To maximize the illumination it is **desirable to use light color walls** and white color ceiling.

- However areas of **high reflectance** in the visual field can become source of reflected glare.



Light Glare

- Glare is produced by **brightness with in the filed of vision** that is sufficiently greater than the luminance to which eyes are adapted.
- Glare causes annoyance, discomfort, or loss in visibility.
- Direct glare is caused by the light source in the filed of view.
- Reflected glare is caused by the light reflected from various surfaces.



- Severe glare may also be caused by direct sunlight coming in either through **windows or rooflights**.
- Window glare can be prevented or reduced by using blinds or tinted glass, and rooflight glare can be effectively reduced by using a white or colour wash.
- The disadvantage of these measures is that they reduce the amount of daylight in the interior.

USE OF INDIRECT (REFLECTED)LIGHTING

- The technique of **indirect lighting** (sometimes called uplighting) uses one or more fixtures to aim light onto the ceiling and upper walls, which act as reflectors and **distribute the light evenly** throughout the room. Indirect lighting is a form of **ambient lighting**.

- Indirect lighting minimizes shadows and reflected glare. It is especially appropriate for rooms with **reflective surfaces** such as computers or televisions. For other critical visual tasks, a supplementary **task light** may be required.

Cont..

- Task lighting provides increased light for specific tasks in a room that may already have some **ambient light**.

- Task lighting is especially useful for seeing small objects or objects of low contrast.

- For example, a person who is sewing would need extra light to easily see fine details.

Cont..

- Task lighting can also provide **increased light** for tasks that require accuracy, such as reading directions on a bottle of medicine or chopping vegetables in the kitchen.
- Task lighting is also useful for workspaces, such as a **workbench or woodshop in the garage**, or a space used for arts and crafts.
- Always consider **the tasks that will be performed** in a room before designing the lighting. Remember that as people age, they need more light for critical tasks.

Cont..

For **highest efficiency**, the ceiling should be painted white, or a very light color. Paint should be matte rather than glossy.

To prevent bright reflected "hot spots" move the light source away from the reflector wall or ceiling.

LIGHT FOR THE AGING EYE

As people **grow older**, less light reaches the back of the eye. Natural changes associated with aging result in reduced vision and increased glare sensitivity. Not only can this be frustrating and debilitating, but it can also lead to additional problems, such as an increased chance of falling.

By using good lighting design, seniors can see better, avoid falls, and sleep better.

Tips on lighting for the aging eye:

Cont..

Provide extra light: Paint walls a light color to increase reflected light, provide flexible task lights, use under cabinet lighting, install fixtures over work areas and place table lamps near reading chairs and beds.

Avoid shadows: Locate a desk, table, or floor lamp to the left of a right-handed person and to the right of a left-handed person. Lighting from the side reduces glare and minimizes shadows on the task.

Avoid glare: To avoid glare, do not install bright fixtures near glossy surfaces, avoid using clear glass fixtures, and shield bulbs from direct view.

Under cabinet lighting

Cont..

Provide orienting information: Use nightlights, glowing switches, and lights along pathways and around doors to help seniors orient themselves to avoid falling. Use contrasting colors to make objects more visible (such as a dark baseboard next to a light color floor).

Provide lighting that better entrains the circadian rhythm, including higher levels of light during the morning and lower levels in the evening and at night.

COST EFFICIENCY OF ILLUMINATION

The cost efficiency of illumination depends on a number of factors, including the type of lighting technology used, the efficiency of the fixtures, and the cost of electricity.

- LED lighting has become a popular choice for illumination due to its energy efficiency and longer lifespan compared to traditional lighting options such as incandescent and fluorescent bulbs.
- LEDs are capable of producing the same amount of light while using much less electricity, resulting in significant cost savings over time.
- In addition to choosing energy-efficient lighting technology, there are other ways to increase the cost efficiency of illumination.

Cont..

- For example, using motion sensors and timers can help reduce energy waste by turning lights off when they are not needed.
- Installing reflective surfaces and positioning fixtures strategically can also improve the effectiveness of lighting and reduce the number of fixtures required.

Overall, the cost efficiency of illumination depends on making smart choices when it comes to technology, installation, and usage. By taking a comprehensive approach to lighting design and management, it is possible to achieve significant cost savings while still providing adequate illumination for the desired application.

SPECIAL PURPOSE LIGHTING FOR ILLUMINATION AND QUALITY CONTROL

Special purpose lighting is an important aspect of human factors engineering that focuses on designing lighting systems that optimize illumination and quality control in different environments. Special purpose lighting can be used in a variety of settings, including industrial and commercial workplaces, healthcare facilities, and even in homes.

In human factors engineering, the goal is to design lighting systems that promote safety, efficiency, and productivity by minimizing visual fatigue, reducing errors and accidents, and improving overall visual comfort. For this reason, special purpose lighting often involves the use of customized lighting configurations that are tailored to specific tasks, work areas, or user needs.

Cont..

Some examples of special purpose lighting include:

- **Task lighting**: Task lighting is used to illuminate specific work areas where precision and accuracy are required, such as in manufacturing or assembly lines, laboratories, and operating rooms. Task lighting is often brighter and more focused than general ambient lighting to provide better visibility and reduce eye strain.

- **Color-corrected lighting**: Color-corrected lighting is used to improve color rendering, particularly in settings where accurate color perception is critical, such as in medical diagnosis, art restoration, or automotive painting.

- **Flicker-free lighting**: Flicker-free lighting is used to reduce the stroboscopic effect that can occur with some LED lights, which can cause headaches, eye strain, and dizziness in some people.

TEMPERATURE

- Temperature is an important factor to consider in designing and maintaining safe and comfortable working conditions.
- Both high and low temperatures can have negative effects on worker productivity, safety, and health.
- In general, ergonomists recommend maintaining a comfortable temperature range between 68-76°F (20-24°C) in indoor work environments
- Employers should also consider individual worker preferences and needs, such as providing access to fans or heaters for those who prefer warmer or cooler temperatures.

EFFECTS OF TEMPERATURE

- In hot environments, workers may experience heat stress, dehydration, and fatigue, which can lead to reduced performance, increased risk of accidents, and even heat stroke.
- To prevent these issues, employers can implement measures such as providing shade or air-conditioned spaces, ensuring adequate hydration, and scheduling work during cooler hours of the day.
- In cold environments, workers may experience hypothermia, frostbite, or decreased dexterity, which can also impact performance and safety.
- To prevent these issues, employers can provide appropriate clothing and personal protective equipment, heated work areas or breaks, and regular monitoring of workers' body temperature and other signs of cold stress.

HUMIDITY

- Humidity refers to the amount of water vapor present in the air.
- It is usually expressed as a percentage of the maximum amount of water vapor the air could hold at a given temperature and pressure, which is known as the "relative humidity.“
- The ideal range of relative humidity in working conditions is typically between 30-60%, with the most comfortable level being around 40- 50%.
- Employers should monitor and maintain proper humidity levels to ensure a safe and comfortable working environment for their employees.
- This can be achieved through the use of humidifiers or dehumidifiers, proper ventilation, and regular maintenance of heating, ventilation, and air conditioning (HVAC) systems.

EFFECTS OF EXTREME HUMIDITY

- High humidity levels can make the air feel heavy and difficult to breathe, which can lead to fatigue and decreased concentration.
- It can also make it harder for the body to cool down, leading to an increased risk of heat-related illnesses.
- On the other hand, low humidity levels can cause dry skin and respiratory issues such as dry throat, nasal congestion, and coughing.
- It can also lead to static electricity buildup, which can damage electronic equipment and create safety hazards.