

Sophomore Architecture Lighting Lecture 1: Daylight / Light Spectrum / Sources Spring 2010

Sophomore Architecture Studio: Lighting

Lecture 1:

- Review of Daylight
- Introduction of Electric Light
- Survey the Color Spectrum
- Summary of Light Sources

Lecture 2:

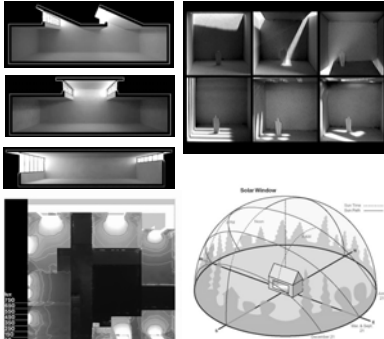
- Controlling Light
- Effects on Materials

Lecture 3:

- Light in Architecture
- Lighting Design Strategies

1

Daylight Design



The art and science of daylighting design is not so much how to provide enough daylight to an occupied space, but how to do so without any undesirable side effects.

2

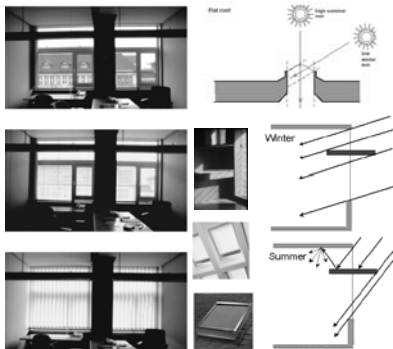
Daylight Design



Daylight design is more than just adding windows or skylights to a space. It is the careful balancing of heat gain and loss, glare control, and variations in daylight availability.

3

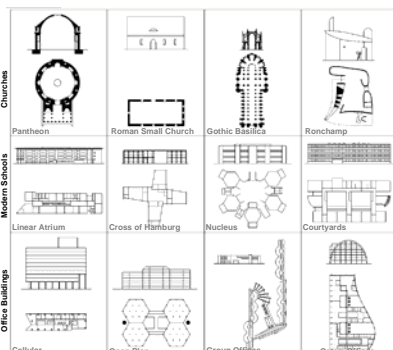
Daylight Design



Successful daylighting designs pay close attention to the use of shading devices to reduce glare and excess contrast in the workspace.

4

Strategies in History



Daylight strategies for different type of buildings types

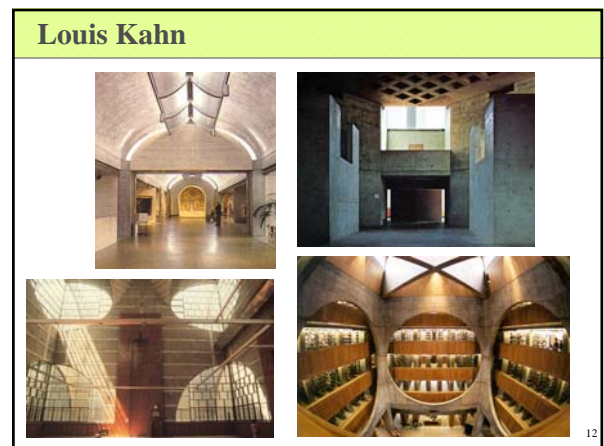
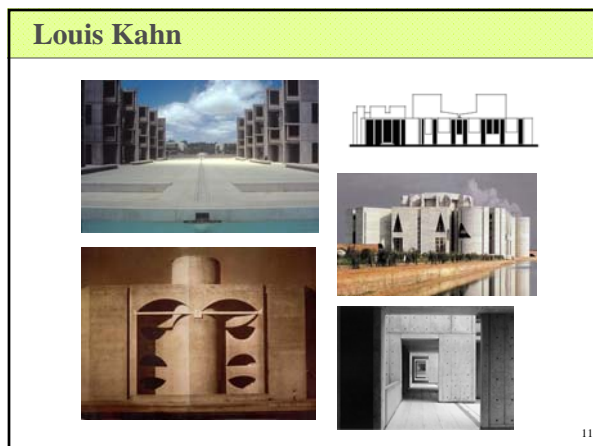
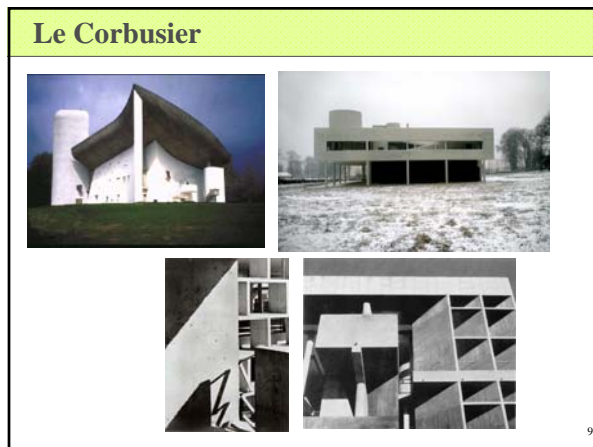
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Strategies in History



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Steven Holl

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New York Times Building

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Joost van Santen

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Joost van Santen <http://www.joostvansanten.nl/works/interior-lighting-projects/>

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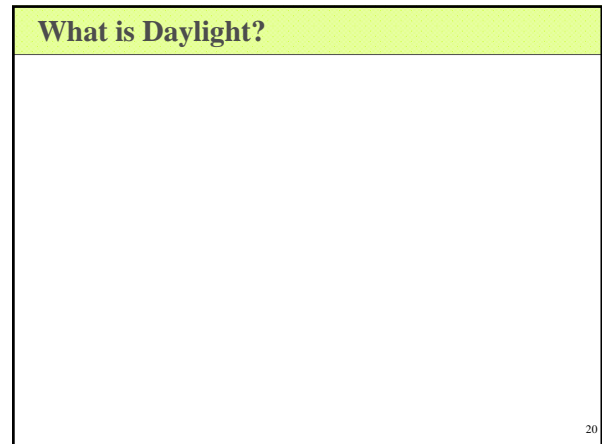
Joost van Santen

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James Turrell

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What is Daylight?

Everyone from scientists and teachers to optometrists and dermatologists are now touting the benefits of natural light.

Following are some of the positive effects sunlight is credited with providing:




- Improves moods and combats depression
- Boosts energy and increases production levels
- Makes interior spaces appear larger
- Renders colours true
- Reduces eyestrain
- Conserves energy (**Free Lighting**)
- Brings the outdoors in

What is Daylight

- People require changing stimuli to remain sensitive and alert
 - Gazing out the window at distant objects provides relief for the muscles of the eye
 - Constantly changing nature of daylight satisfies our **biological** and **psychological** needs for change
 - Comfort requires moderate changes
 - Monotony will cause fatigue, but so will over stimulation.
 - Excessive contrast provides emotional appeal but also impairs visual performance
 - The sudden appearance of a beam of sunlight on a task will provide momentary change and relief – but if it remains it will cause visual fatigue and stress

What is Daylight?



- Daylight is **Variable**
 - The color of daylight changes with the time of day
 - The cleanliness of the atmosphere effects daylight
 - The interrelation (or bouncing of light) of the surrounding objects
- The intensity of the sun changes with...
 - the time of day...
 - the time of year...
 - the latitude of the site
- The luminance (or brightness) of daylight depends on whether the light is coming from an overcast sky, from a clear sky only, or from a clear sky and direct sunlight


Daylight Components

- Daylight has two components:
 - **Sunlight:** the directional beam emitted by the sun
 - directional
 - piercing and very strong, warmer in both temperature and color
 - gives shape to a building
 - need to control its direct penetration into critical visual task areas
 - *Spaces illuminated by the rays of eastern and western sunlight radically change on a daily, hour-by-hour basis and are extremely difficult to adapt for critical visual task environments*
 - **Skylight:** the diffuse reflection of light particles in the atmosphere
 - can be diffuse light of the clear, cloudy, or overcast sky
 - can be similar in all orientations
 - is soft, cool in both temperature and color
 - *Spaces illuminated with diffuse southern sunlight change on a seasonal basis and are adaptable to critical visual tasks.*

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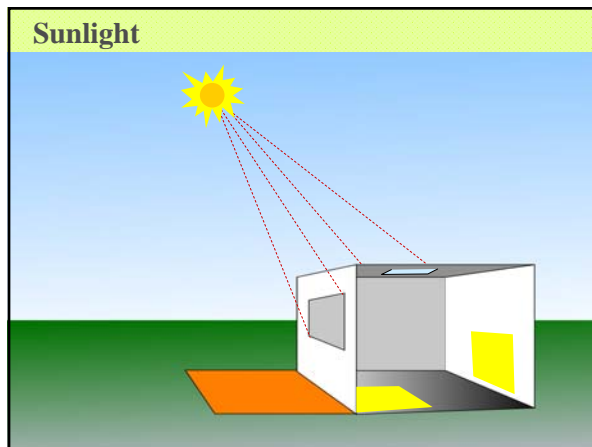
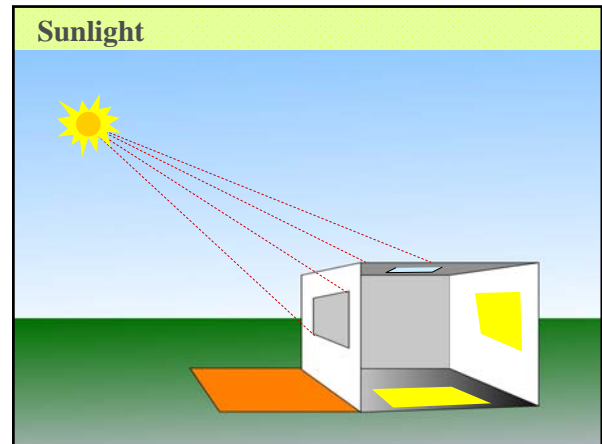
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Sunlight




- Direct **Sunlight** is usually an impractical source for interiors for task lighting
 - Constantly changing
 - Will require shielding to block direct glare and heat gain
 - Sunlight, for critical seeing, can cause...
 - excessive luminous differences that result in discomfort and poor visibility
 - high contrast in the field of view inhibits the eyes ability to adjust
 - leads to visual fatigue
 - disturbing the accommodation needed for clear vision

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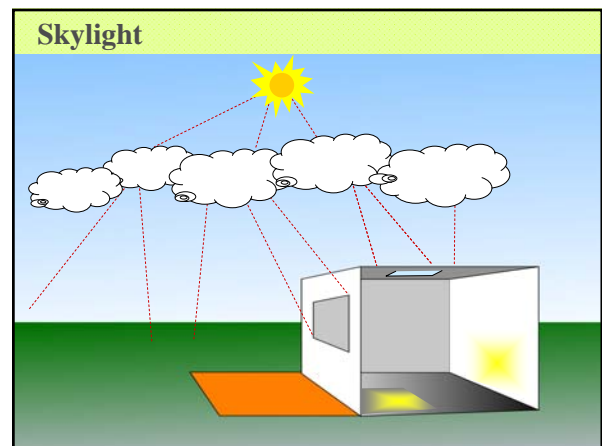
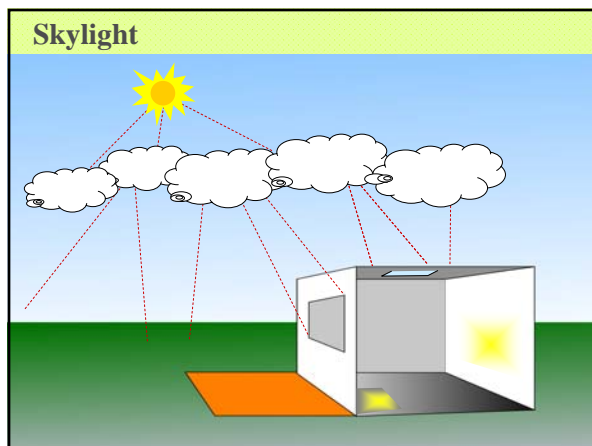


Skylight



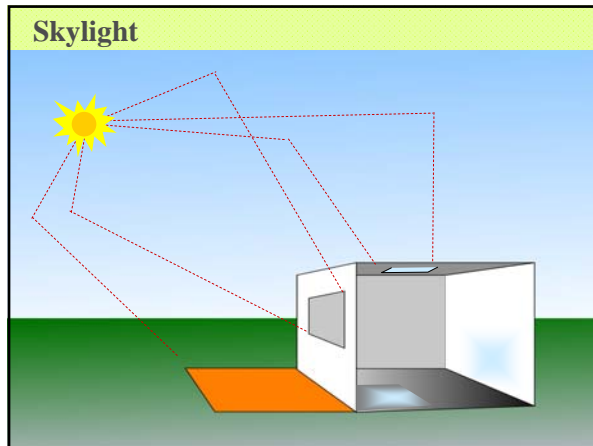
- **Skylight** is a useful source without shielding
 - Gradual changes through the day
 - Diffuse
 - With building configuration or controls skylight can be acceptable for horizontal task lighting or displaying art
 - It is used with less control to light noncritical seeing areas such as corridors, stairwells, cafeterias, and seating areas

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Daylight vs Views

A view of the sky provides information about the time of day, which helps maintain our biological cycles.

Varying light as a cloud passes in front of the sun provides stimulation, which helps reduce monotony.

Daylight and view do not necessarily go together and often are achieved through different openings.

The criteria for producing a view to the exterior are different from the criteria for producing good interior daylight.

Daylight and Health

Daylight and Health

All life on earth evolved under both sunlight and darkness. This light and dark cycle not only allowed for various activities, but evolved to regulate all species circadian rhythm – internal biological clock.

Daylight and Health

Everyone loves a bright sunny space, but who would have thought that those good ole' natural rays could have such a profound impact on you?

Recent studies reveal that natural light not only brightens your home and work environment, but actually boosts your spirits and keeps you healthier.

An Indoor Society- Lifestyles today have changed to the extent that as much as 90 percent of our time is spent indoors, away from natural light.

- Daniel F. Kripke, a researcher with the University of California San Diego, surveyed adults in San Diego, who wore wrist meters to register the amount of sunlight they received during the day.
- The study found that the majority was only exposed to sunlight for less than one hour per day and some did not go outdoors at all during a 48-hour period.

Of course, most of us do not have the luxury of being outdoors as much as we would like. That is why daylighting – techniques which optimise the use of natural light to illuminate interiors – is becoming increasingly popular not only for its ability to dramatically transform a room, but also for its natural healing powers.

Daylight and Health

The power of light to rejuvenate the body and mind – treating everything from lethargy to "winter blahs" to clinical depression – has been suspected for thousands of years, but only recently have scientific studies revealed evidence of the correlation.

- One of the largest studies on the use of light to treat clinical depression was published in 1992 in the journal *Biological Psychiatry*. Dr. Kripke administered light treatment to 25 depressed hospitalized patients at a VA hospital.
 - *Patients who were exposed to natural white light were significantly less depressed than those in electric light.*
- An estimated 90 percent of humans suffer from seasonal mood changes during the winter months and up to 10 percent of those suffer from the condition known as seasonal affective disorder, or SAD, characterized by fatigue, gloom, change in appetite, fitful sleep and despair.
- The most effective treatment for these symptoms is, quite naturally, exposure to more light. Studies indicate that the time between sunrise and sundown is the key factor in SAD, rather than the lack of sunny days or cold temperatures.

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Daylight and Health

EFFECT OF LIGHT ON THE IMMUNE SYSTEM

MOOD CIRCADIAN SEASONAL

IMMUNE SYSTEM

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Daylight and Health

For centuries, it was believed that light only effected our visual acuity - our ability to see. Light enters our eye then converted by our cones and rods in our retina to a chemical, that then travels thru the optic nerve to be processed by the brain.

optic nerve chiasm lateral geniculate optic radiation Primary visual cortex

retina

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Daylight and Health

Recent research suggest that UV wavelengths are read by ganglion cells in our retina, then travel thru the optic nerve to the hypothalamus. Our **circadian rhythm** regulates the production of hormones effecting our immune system.

CIRCADIAN

PHOTOSENSITIVITY

Visible light through the eye stimulate a cascade of hormones which modify the Human Immune

Circadian Rhythm - hormonal changes

- Pineal: sleep/wake
- Pituitary: growth, blood pressure, reproduction
- Adrenal: stress
- Thyroid: metabolism

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Daylight and Health

- Daylight is an effective stimulant to the human visual system and human circadian system
- **Circadian Rhythms** (also know as your internal clock) are a basic part of life and can be found virtually in all plants and animals, including humans
 - The role of the circadian system is to establish an internal representation of external night and day
 - The internal representation is not a passive response to external conditions, but rather is **predictive to external conditions of conditions to come!**
- **Sight is not needed to control Circadian Rhythms!!!**
 - - as long as the optic nerve is intact, blind people still receive visible light signals

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Daylight and Health

- **Circadian System**
 - The human circadian system involves three components:
 - An internal oscillator in your brain
 - A number of external (your eyes, your skin) sensors that reset or entrain your internal oscillator
 - A messenger hormone, **melatonin**, that carries the internal "time" information to all parts of the body thru the blood stream
 - In the absence of light, and other cues, the internal oscillator continues to operate but with a period longer than 24 hours
 - External stimuli is necessary to reset your internal oscillator to a 24 hour period and to adjust for the seasons
 - The light - dark cycle between day and night is one of the most potent of the external stimuli for your internal oscillator

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Daylight and Health

Circadian rhythm is an approximate daily periodicity, a roughly-24-hour cycle in the biochemical, physiological or behavioral processes. Disruption to rhythms usually has a negative effect.

Circadian Rhythm - imbalance

- Jetlag
- Seasonal Depression
- Shift Work Dysfunction
- Sleep Disturbances
- Carbohydrate Cravings
- Confusion/Poor Coordination
- Malaise/Blues
- Susceptible to Disease


Sleep Disturbances
Light at Night
Bright visible light - blocks the production of melatonin

Light at Night
Risk Factor for Breast and Prostate Cancer

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Daylight Qualities:



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Daylight Qualities: veiling reflection



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Daylight Qualities: a magical sprite



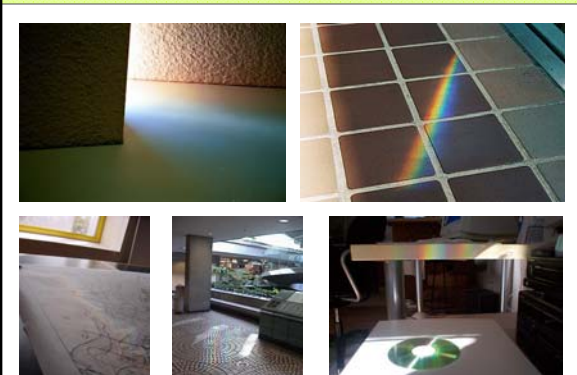
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Daylight Qualities: dynamic daylight



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Daylight Qualities: daylight prismatically deconstructed



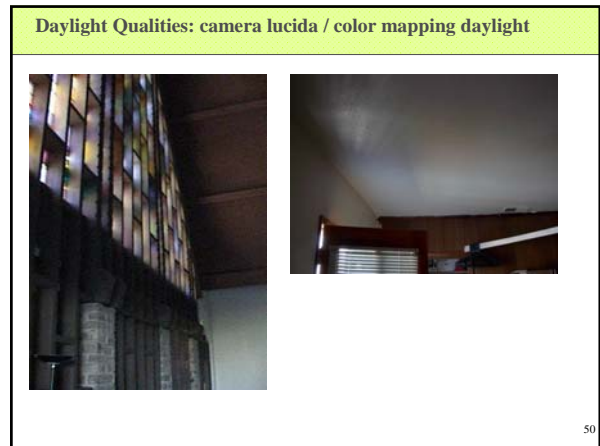
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Daylight Qualities: leaking light

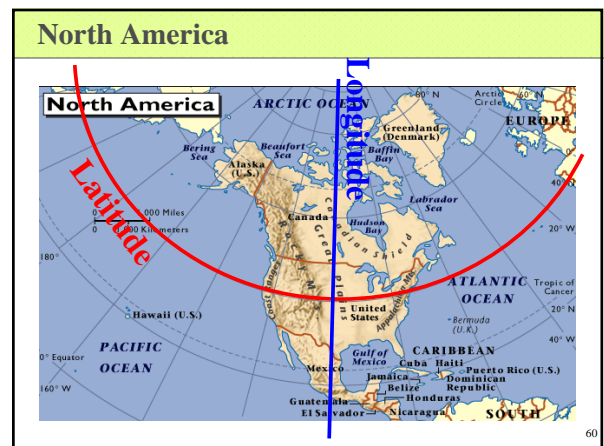
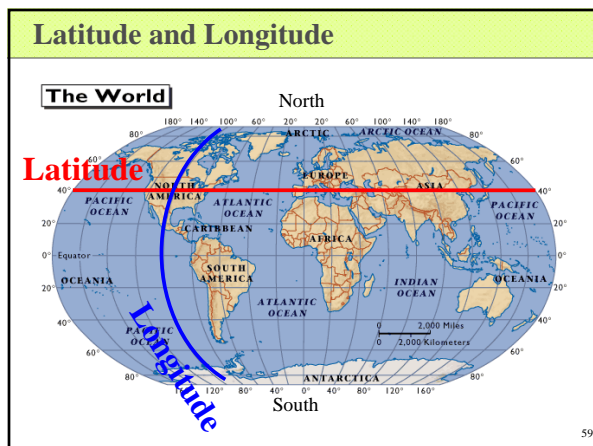
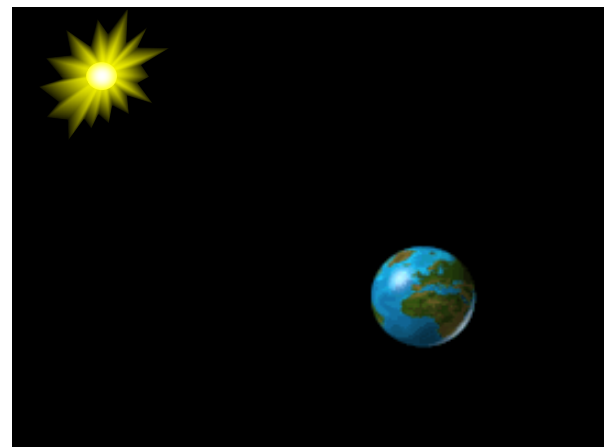
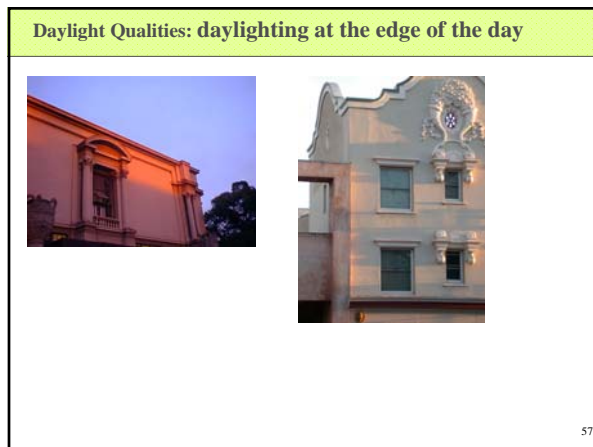
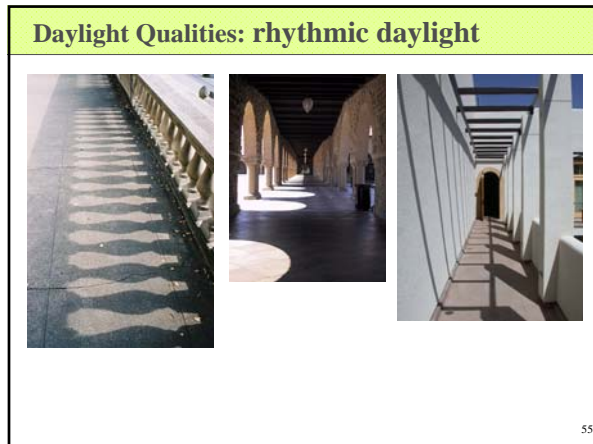


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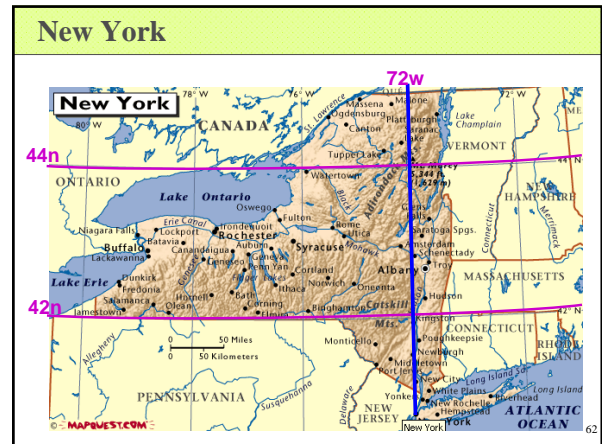
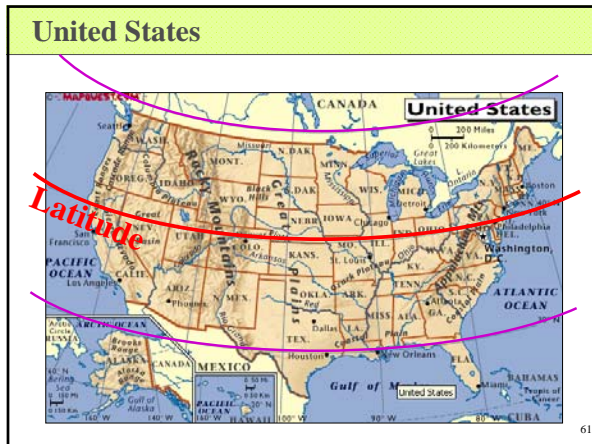


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Site Location

Country/City	Latitude		Longitude	
	Degrees	Radians	Degrees	Radians
Canada				
Ottawa, ON	45	0.79	76	1.33
Montreal, PQ	46	0.80	74	1.29
Toronto, ON	44	0.77	79	1.38
Vancouver, BC	49	0.85	123	2.15
Winnipeg, MB	50	0.87	97	1.69
Mexico				
Mexico City	19	0.33	99	1.73
United States				
Anchorage, AK	61	1.06	150	2.62
Big Rapids, MI	44	0.77	85	1.48
Boulder, CO	40	0.70	105	1.83
Chicago, IL	42	0.73	88	1.54
Cleveland, OH	41	0.72	82	1.43
Dallas, TX	33	0.58	97	1.69
Honolulu, HI	21	0.37	158	2.76
Los Angeles, CA	34	0.59	118	2.06
Miami, FL	26	0.45	80	1.40
New York, NY	41	0.72	74	1.29
Philadelphia, PA	40	0.70	75	1.31
Seattle, WA	48	0.84	122	2.13
Troy, NY	43	0.75	74	1.29
Washington, DC	39	0.68	77	1.34

Latitude and Longitude of Some North American Cities

The site location is specified by a latitude l and a longitude L . Latitudes and longitudes may be found in any standard atlas or almanac. Chart shows the latitudes and longitudes of some North American cities.

Conventions used in expressing latitudes are:
 Positive = northern hemisphere
 Negative = southern hemisphere

Conventions used in expressing longitudes are:
 Positive = west of prime meridian (Greenwich, United Kingdom)
 Negative = east of prime meridian

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Solar Position

The rotation of the earth about its axis, as well as its revolution about the sun, produces an apparent motion of the sun with respect to any point on the earth's surface.

The position of the sun with respect to such a point is expressed in terms of two angles:

- solar altitude**, which is the vertical angle of the sun above the horizon, and
- solar azimuth**, which is the horizontal angle of the sun from due south in the northern hemisphere.

The sun's position in terms of solar altitude (a) and azimuth (A) with respect to the cardinal points of the compass.

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Solar Position

<http://www.susdesign.com/>

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Solar Position

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Solar Position

The position of the sun is specified by the solar altitude and solar azimuth and is a function of site latitude, solar time, and solar declination.

Animation showing changing sun-path on the 21st day of each month for latitude -25°.

Solar Position

Solar Position: Sun Path Diagrams

Sun path diagrams can be very useful (they combine coordinates of time and position) and allow analysis of:

1. Sun's position at any time
2. A building's radiation need (using month vs hour grid)
3. Shading from the site - horizon profiles
4. Solar geometry - overlays for profile angle
5. Radiation impact
6. Shading from some shading devices
7. Availability of natural illumination

The Libbey-Owens, Ford Sun Angle Calculator (SOPAC) - created by architects for generations

<http://www.sbsc.org/resources/sac/>

Solar Position: Sundial

Solar Position: Sundial

www.shadowspro.com

A genuine sundial or astrolabe at your home

Shadowspro is a program used to design sundials and astrolabes. It can be used to generate, edit and print sundial plans. Shadowspro will calculate everything and print the drawing according to the user's preferences.

Shadowspro is acclaimed by thousands of users around the world and by hundreds of professional solar authors and astronomers. Shadowspro has been awarded the Grand International Award (Grand International de France).

Key points of Shadowspro:

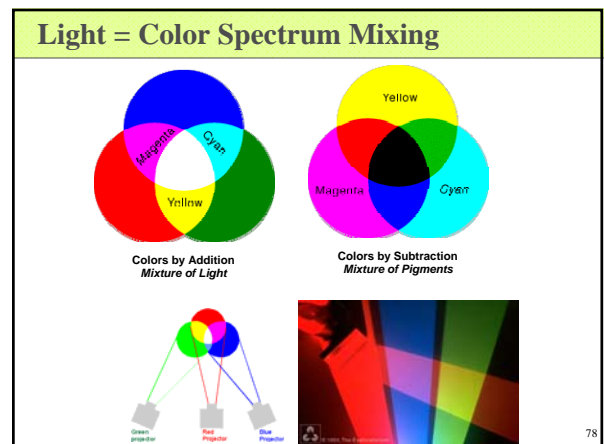
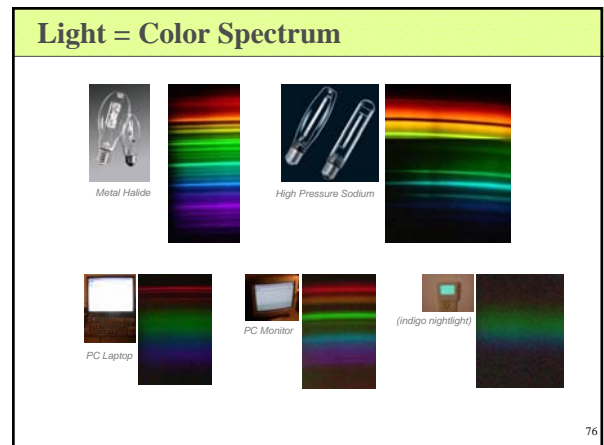
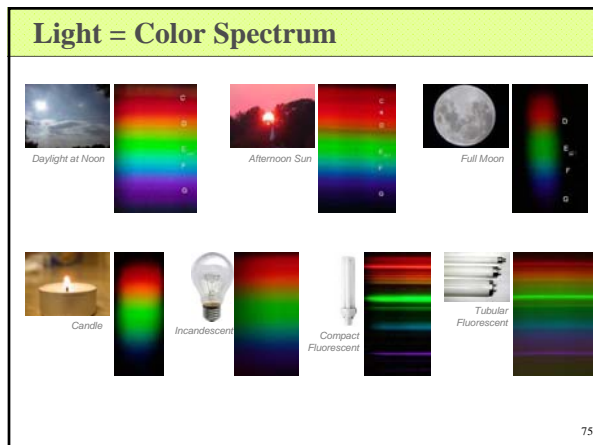
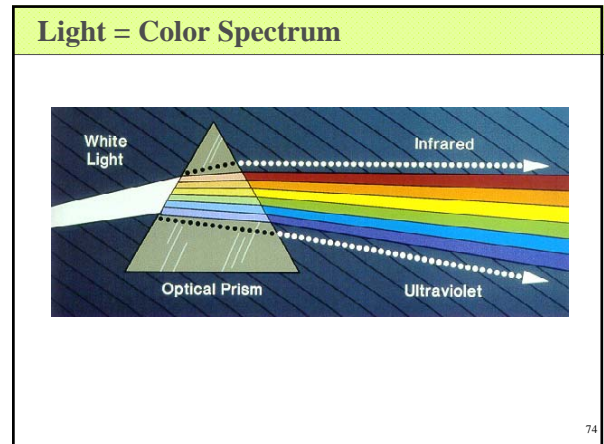
- Free of charge in its entire life!
- Two-dimensional design: Shadow layout and Shadow file
- Accurate as the physical software for the design of sundials and astrolabes
- Calculations are done in the background at high speed
- Unlimited number and position of the dial's face
- Interactive window (position of the face and radius using the mouse)
- Dynamic drawing on grid, 30, 60, 90 and 120 degrees
- Offers complete adjustment of the dial and also the hour diagram
- Various styles available with color palette of the background and gridlines
- Adjustable window, color palette and grid lines
- Support astrolabes astrolabes (dial and face)
- Includes a large database of more than 2000 locations with latitude, longitude and time zone
- Working with a 32-bit architecture
- Available in 12 languages
- Designed for Windows XP and Windows Vista

Daylight Spectrum

OPTICKS: OR, A TREATISE OF THE REFLECTIONS, REFRACTIONS, INFLECTIONS AND COLOURS OF LIGHT. By Sir Isaac NEWTON, KNT.

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Color Spectrum

Incandescent Lamps and Natural Daylight produce smooth, continuous spectra.

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Daylight Color Spectrum

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Correlated Color Temperature

Kelvin Temperature			
Cool	9000	North Blue Sky	
	8500		
	8000		
	7500		
	7000		
	6500	Overcast Day	
Daylight Fluorescent	6000		
Cool White Fluorescent	5500	Mercury	
	5000	Direct Sunlight	
4100K Fluorescent	4500		
	4000	Metal Halide	
3500K Fluorescent	3500		
3000K Fluorescent	3000	3000K Metal Halide	
Warm White Fluorescent	2500	Halogen	
	2000	Incandescent	
Warm	1500	High Pressure Sodium	
		Fire / Candle light	
		Hot Embers	

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Color Spectrum: Daylight Effects

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Seeing Color

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http://www.gelighting.com/na/business_lighting/education_innovations/learn_about_light_color_lamp.htm

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Color Rendering Index

how a light source renders the color of objects

High CRI light makes virtually all colors look natural and vibrant.

Low CRI causes some colors to appear washed out or even take on a completely different hue.

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Color Rendering Index

how a light source renders the color of objects

Comparing the colour appearance under different light sources (left):
Test swatches under different light (right)

The color rendering of a light source is an indicator for its ability of realistically reproduce the color of an object.

Following the CIE (International Lighting Commission), color rendering is given as an index between 0 and 100, where lower values indicate poor color rendering and higher ones good color rendering.

The color rendering of a light source is compared a continuous spectrum source, such as incandescent - to daylight if its CCT is >5000K.

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Light = Energy Waves

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Light = Color

Figure 1

Spectral Power Distribution Curves (SPD) provide the user with a visual profile of the color characteristics of a light source. They show the radiant power emitted by the source at each wavelength or band of wavelengths over the visible region (380 to 760 nm).

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Light Technologies

New Developments

There was a need to improve the light several ways:

1. The need for a constant flame, which could be left unattended for a longer period of time
2. Decrease heat (and smoke) for interior use
3. To increase the light output
4. An easier way to replenish the source....thus, the development of gas and electricity
5. Produce light with little waste or conserve energy

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Early Electric Light Technologies

arc lamps early in the 19th century

Fig. 11-7. Century's illumination of the city early for street lighting on the Place de la Concorde in Paris, 1824.

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Early Electric Light Technologies

Early light bulb with a platinum filament. Although functional, its cost made the bulb commercially impractical.

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Early Electric Light Technologies

Edison and Swan:

- Developed the incandescent carbon filament lamp in late 1870s
- Edison designed a complete electrical system and a lamp that could be mass-produced

Thomas A. Edison holding one of his famous light bulbs

A drawing of an early light bulb design by Edison. Edison tried numerous different materials and designs before he was successful in developing a practical incandescent bulb.

A modern light bulb

1907

The first commercial tungsten filament for incandescent lamps became available in the United States. Tungsten wire manufacturing was still costly and difficult, but the problem was to soon be overcome.

A modern tungsten light bulb filament

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Electric Sources

Light Fixture

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Electric Sources

Bulb

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Electric Sources (Lamps)

<p>INCANDESCENT LAMPS (filament)</p> <p>Incandescent</p> <p>Halogen</p>	<p>DISCHARGE LAMPS</p> <p>Fluorescent Linear</p> <p>Compact</p>	<p>High Intensity (HID)</p>
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Lamps = Sources

Points

Blobs

Lines

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Points

97

How Incandescent Lamps Work

98

Points: General Purpose/ A-Lamps

STANDARD SHAPES

A 19

Soft White Inside Frost Clear Natural Light Softone Pastels

A 21

3-Way Soft White 3-Way Natural Light Clear 3-Way Softone Pastels PS 25

99

Points: B, BA, C, CA, and F

Find a bulb by shape: **DECORATIVE INCANDESCENT FLAMES**

100

Points: G – Lamps

Find a bulb by shape: **DECORATIVE INCANDESCENT GLOBES**

G 14.5 G 35 G 55
Clear & White Clear & White Natural Light

G 35 G 30 G 40
Chrome - Top White Clear or White

101

Points: Specialty / T and S - Lamps

Find a bulb by shape: **SPECIALTY**

T SHAPES

S SHAPES

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Points: Halogen Lamps

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How Halogen Lamps Work

104

Light = Color

Natural Light Daylight

Electric Light Incandescent

Incandescent Lamps and Natural Daylight produce smooth, continuous spectra.

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Points: LED's

- Light-emitting diodes (LEDs):
 - Semi-conductor devices that have a chemical chip embedded in a plastic capsule

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How LED's Work

Anatomy of a White Light Emitting Diode

Figure 7

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How LED's Work

Current flows across this junction

No current flows across this junction

When the negative end of the circuit is hooked up to the N-type layer and the positive end is hooked up to the P-type layer, electrons and holes start moving and the depletion zone disappears.

When the positive end of the circuit is hooked up to the N-type layer and the negative end is hooked up to the P-type layer, free electrons collect on one end of the diode and holes collect on the other. The depletion zone gets bigger.

The interaction between electrons and holes in this setup has an interesting side effect -- it generates light!

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How LED's Work

When current flows across a diode, negative electrons move one way and positive holes move the other way.

CONTINUE >

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Points: LED's

110

Points: LED's

111

LED

112

LED

<http://www.lif-germany.de/film/mov07793.mpg>

113

Points: Compact Fluorescent

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Lamp Pros and Cons

- Poor spectrum, poor color, poor rendering (CRI = 90-40)
- Screw base difficult to dim ("dims to greenish brown color..."), pin base requires special ballast and control
- Long Life (limited to 3-hour on cycle)
- High efficacy rating (lumen/watt)
- Cannot replace point source bulbs in point-source fixtures, Cannot replace all 1000+ incandescent bulb types
- Contains toxic mercury (if incandescent is banned, 50,000 lbs of mercury will be introduced into landfills upon disposal every 7 to 10 years)
- High embodied energy (several times that of incandescent), most are made in China, which uses coal-fired methyl mercury producing power plants
- Customer Dissatisfaction: limit uses, high initial cost; high failure rate (many fail after 2 to 20 hours)

- Excellent color, reliable, highest color rendering (CRI 100)
- Dims easily without specialized equipment.
- Dimming extends life and energy consumption.
- Halogen vs incandescent are 30% more efficient, approach CFL efficiency with controls and heat fluorescents in many categories.
- Do not have negative disposal impacts, fully recyclable
- More efficient to produce, i.e., less embodied energy

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What is in the lamp?

- glass
- steel
- a small amount of high temperature plastic insulation
- (lead free?) solder
- plating material for exposed metal, probably nickel
- phosphors **
- mercury + mercury vapor **
- silicon (in ICs, transistors, MOSFETs, diodes, etc.)
- fiberglass and epoxy resins (PCB, semiconductor cases)
- aluminum (electrolytic capacitor)
- various plastics (main housing, film capacitors)
- ferrites / ceramics (resistor bodies, choke cores)
- copper wire and PCB traces

** are either toxic, or may be toxic when mixed with other chemicals in landfill.

- glass
- steel
- a small amount of high temperature plastic insulation
- (lead free?) solder
- plating material for exposed metal, probably nickel
- tungsten
- inert (and naturally occurring) gas

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CHANGE FOR THE BETTER WITH ENERGY STAR

Frequently Asked Questions
Information on Compact Fluorescent Light Bulbs (CFLs) and Mercury
May 2007

How should I clean up a broken fluorescent bulb?
The following steps can be performed by the general public:

- Open a window and leave the room for 15 minutes or more.
- Carefully scoop up the fragments and powder with stiff paper or cardboard and place them in a sealed plastic bag.
- Use disposable rubber gloves, if available (i.e., do not use bare hands). Wipe the area clean with damp paper towels or disposable wet-wipes and place them in the plastic bag.
- Do not use a vacuum or broom to clean up the broken bulb on hard surfaces.
- Place all cleanup materials in a second sealed plastic bag.
- Place the first bag in a second sealed plastic bag and put it in the outdoor trash container or in another outdoor protected area for the next normal trash disposal.
 - Note: some states prohibit such trash disposal and require that broken and unbroken lamps be taken to a local recycling center.
- Wash your hands after disposing of the bag.
- If a fluorescent bulb breaks on a rug or carpet:
 - First, remove all materials you can without using a vacuum cleaner, following the steps above. Sticky tape (such as duct tape) can be used to pick up small pieces and powder.
 - If vacuuming is needed after all visible materials are removed, vacuum the area where the bulb was broken, remove the vacuum bag (or empty and wipe the canister) and put the bag or vacuum debris in two sealed plastic bags in the outdoor trash or protected outdoor location for normal disposal.

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Fluorescent Recycling

Step 1

RECYCLEBARK containers are delivered to Veolia by FedEx Ground for processing. Materials are received and entered into Veolia's hazardous waste tracking system.

Step 3

It is best to be process control of manually opening the packaged containers and placing the lamps into the feed mechanism. The lamps are oriented into a chamber where a breaker performs an initial portion size reduction of the lamps.

Broken lamp pieces are then crushed to release a greater particle size reduction and transferred to a primary separator to separate the larger components (aluminum and caps).

Step 2

Received materials are sent to processing.

Although there are variations between the equipment used at each Veolia facility, all lamp-recycling processes utilize a dry separation process.

Step 4

The remaining components are then further separated, generating three process streams: glass cullet, glass fines, and phosphor powder.

Of total bulb weight, roughly 90% is recovered as glass, 2% as aluminum, less than 2% as phosphor powder and less than 1% as mercury for refining.

Mercury contaminated phosphor powder is returned to reclaim mercury.

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Blobs

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"Blob" Source Halogen Lamps

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Sophomore Architecture Lighting Lecture 1: Daylight / Light Spectrum / Sources Spring 2010

Reflection
Rays are Parallel

Parabola or Parabolic Reflector
Typically Specular Finish

Rays converge
2 foci

Ellipse, Ellipsoidal, or Elliptical Reflector
Typically Specular Finish

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Blobs: PAR, MR, R

Find a bulb by shape: **FLOOD/SPOT**
FOR INDOOR USE

HALOGEN MINI REFLECTORS

MR 11 MR 16 GU 10

HALOGEN REFLECTORS

BR 30 BR 40

HEAT LAMPS

BR 40

INCANDESCENT REFLECTORS

R 14 (MEDIUM INTERMEDIATE) R 16 BR 19 R 30 Director BR 30 BR 40

DAYLIGHT REFLECTORS

R 30 (Round of Light) BR 30 (Round of Light)

ENERGY SAVERS

BR 30

COLORLED

R 30 (Aurora, Aurora, Aurora)

PLANT

BR 30 (Plant)

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Blobs: PAR - Lamps

Find a bulb by shape: **FLOOD/SPOT**
FOR INDOOR & OUTDOOR USE

HALOGEN

PAR 16 PAR 30 PAR 30L PAR 30L PAR 38

INCANDESCENT

PAR 38 (Green, Red, Blue, Amber, Yellow) BR 38

ENERGY SAVERS

BR 30

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Blobs: LEDs

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Lines

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Fluorescent Lamps

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How Fluorescent Lamps Work

Inside a Fluorescent Lamp

The Physics of Fluorescent Lamps

- Free electrons (e⁻) and ionized mercury atoms (Hg⁺) are accelerated by the electric field.
- An electrical discharge is passed through the center of the lamp.
- Mercury atoms and ions are ionized by the electric field and the heat of the discharge.
- The energy of the electrical current causes the mercury to emit light.

continue >

T5 .625" Diameter or 5/8"
T8 1" Diameter or 8/8"
T12 1.5" Diameter or 12/8"

How Fluorescent Lamps Work

How the Starter Switch Works

- Initial current causes electrical arcs between electrodes, which ionize gas.
- Heat from the arcs causes thermionic emission, which ionizes the mercury, which ionizes the argon.
- The ionized argon ionizes the mercury and returns to its original position. Current flows through the ballast and gas in the tube.

How Fluorescent Lamps Work

How Fluorescent Lamps Work

Rapid start and two pins that start the electrical circuit.

Press the switch to turn on the light!

How Fluorescent Lamps Work

Which Lamps Need Ballasts

All arc discharge lamps such as fluorescent and high intensity discharge (HID) require ballasts for proper operation. Without a ballast, these lamps will not work.

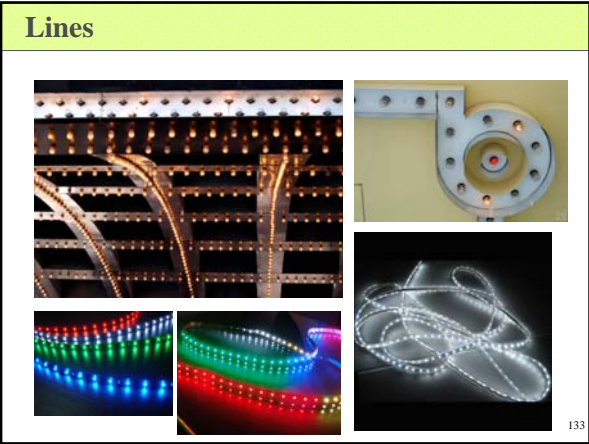
Screw-in compact fluorescent lamps include an extremely small ballast built into the plastic base where the socket is located.

Fluorescent Lamps produce a combined spectrum... a non-continuous or broad spectra with gaps from their phosphor, plus UV from the mercury discharge.

Neon Lamps

ten digits of a Z560M Nixie Tube.

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Spring 2010



Sophomore Architecture Studio: Lighting

Lecture 2:

- Controlling Light
- Effects on Materials

Lecture 3:

- Light in Architecture
- Lighting Design Strategies

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