

# Making Light: Electric Sources

www.iesnyc.org

**NYC Student Lighting Competition**

Since 2000, the New York City Section of the IES has invited students from New York City Art and Design schools to participate in a city-wide design competition. The competition empowers students to explore light as an art form, demonstrate light as a stimulus, and prove light as a valuable medium.

Every year, students in lighting, architecture, interior design, art, product design, photography and electrical engineering programs have submitted projects, resulting in a diverse showcase of ideas and interpretations on a single theme.

**Participating Schools**  
Pratt Institute, Parsons the New School for Design, Fashion Institute of Technology, Cooper Union, School of Visual Arts, New York School of Interior Design, and Fordham University.

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**Links to Past Competition Winners:**

- 2013 IllumNOTES
- 2012 Fraction/Refraction
- 2011 Revealing Shadows
- 2010 Liminal Luminosity
- 2009 Audible Light
- 2008 Evocative Luminance
- 2007 Immersive Lightscapes
- 2006 Illusion by Light
- 2005 Evolving Shadows
- 2004 Luma Lines

Monday, February 24, 2014  
Call for Entries: 2014 Student Lighting Competition

**IESNYC 2014 NYC Student Lighting Competition**  
*A Light Touch*

The IESNYC Student Competition returns in 2014 with "A Light Touch."

**The Challenge:**  
Students are challenged to create a 3D study on how light can define a tactile sensation or tangible experience as an illuminated visual experience. The work need not be an interactive experience of touching materials, but rather a visible interpretation of the sensation encountered. Can you touch with your eyes?

**STUDENTS: SUBMIT YOUR ONLINE APPLICATION HERE**  
Applications accepted through Feb. 24th

**Event:**  
The Helen Mills Theater 137 West 26th Street, New York City.  
Tuesday, March 4th, 2014  
Student Setup: 7:00 AM - 1:00 PM  
Public Exhibition 6:00 PM - 10:00 PM  
Keynote Speaker 8:00 PM - 9:30 PM

**Prizes:**  
1st Place: \$2,000 & Prize Trip  
2nd Place: \$1,000  
3rd Place: \$500  
Additional prizes may be available

**Frequently Asked Questions.pdf**  
For additional information, email us at [studentcompetition@iesnyc.org](mailto:studentcompetition@iesnyc.org)

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# Making Light: Electric Sources



NEW YORK CITY SECTION  
630 LaGuardia Place  
New York, New York 10022  
718.633.6400  
www.illuminatingnyc.com

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New York, New York 10022  
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**FREQUENTLY ASKED QUESTIONS**

1. I live out of New York City. May I submit?  
Eligibility is for students attending a foreign college or university located in New York City Boroughs, Shinnecock, Seneca, Cayuga, and Otsego Island or the New York counties of Columbia, Dutchess, Greene, Orange, Putnam, Rensselaer, Sullivan, Ulster, Westchester) of the former Metropolitan Districts.
2. Can teams of students submit one submission?  
Yes. When submitting your application please list one student name as the primary contact, and include the other students names in the "Notes or Comments" field.
3. Are presentation boards required?  
No. Presentation boards with your submission are not required. You may include a brief description or instructions, but these are not required and not only at the discretion of the judging panel.
4. Are we required to present our submission to the judges?  
No. Presentation by students is not required or allowed. Judging is allowed to the public.
5. Should I bring an extension cord?  
Yes. Bring additional extension cords or adapter plugs if your piece has several plugs. (Please bring three prong adapters for grounded plugs).
6. Are batteries allowed?  
Yes. Bring additional batteries in case your piece weak or loses power.
7. Are cameras allowed?  
No. No cameras or open phones are allowed.
8. May I submit photographs?  
While you may include photographs or images as part of your submission, this competition is not a photography competition. Photographs may be submitted with your optional description, but these are not required.

Is this competition? Do I retain ownership of anything of my submission. Entries will be on public display by the NYCCY. Winners name, school.

ESBY for a public exhibition. All submissions must be received by Wednesday, March 2, 2011. Any submissions that are received after this date will be discarded.

allowed. We recommend your submission team appear on site.

Yes, use a table, against a wall, or hanging from the ceiling. We recommend you include with your entry a base or stand to be viewed at eye level.

allowed.

and a white ceiling. Lights in the space will be off or dimmed.

pins, nails, staples, or electrical shock are adherent to walls that may span floor or walls are not allowed.

Your object can sit on a table or the floor, hang from the ceiling, or mount or lean on a wall. Keep in mind how an observer may respond, interact, or move around your object.

All projects may have a title, incorporate at least one electric light source, and *be easily transportable in a NYC cab.*



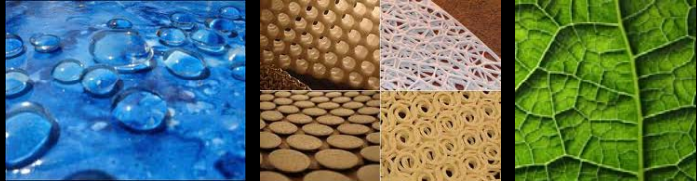




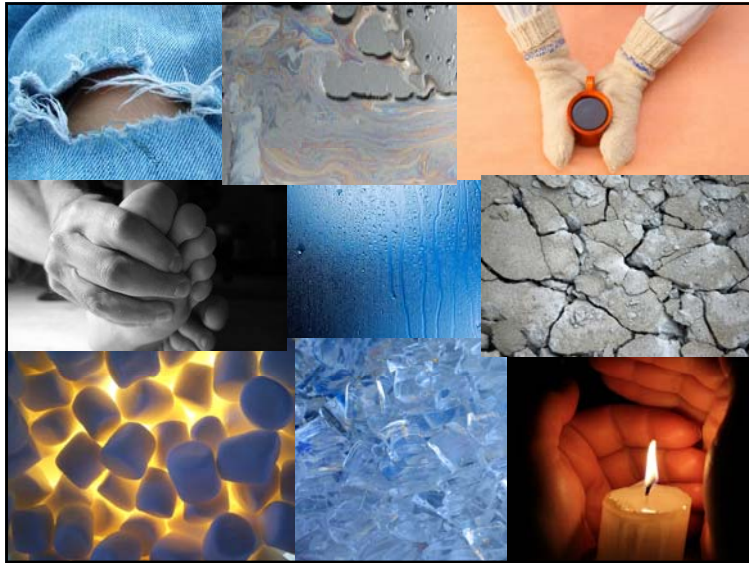



One way of seeing is touching with your eyes – while our brains process information received from our eyes, do you need to touch something to understand how it feels?

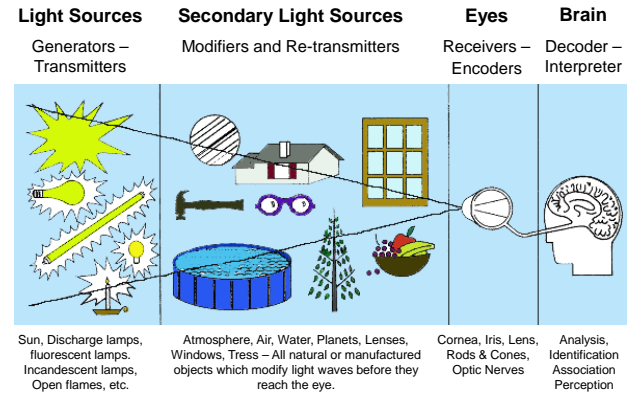
The challenge is to interpret and express the theme in the form of an abstract 3-dimensional lighting experience constructed of your choice of materials. Since the object need not be interactive, what visual effect can you create imply a tactile experience?



# Making Light: Electric Sources



## Visual System



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## What Makes Light: The Sun



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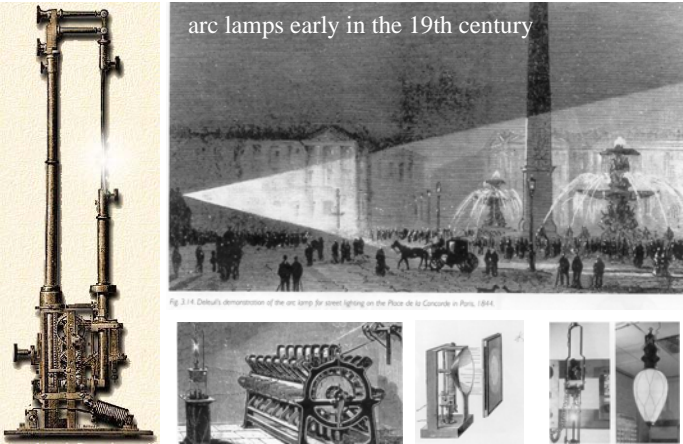
## What Makes Light: Fire



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# Making Light: Electric Sources

## Early Electric Light Technologies



arc lamps early in the 19th century

Fig. 2.14. Dohut's demonstration of the arc lamp for street lighting on the Place de la Concorde in Paris, 1841.

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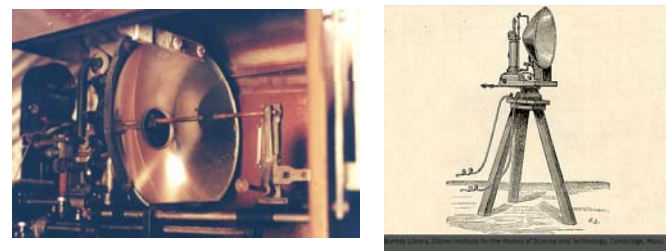
## Early Electric Light Technologies



Fig. 2.15. Jablochhoff candles were soon used in large numbers to light the street and public places of Paris.

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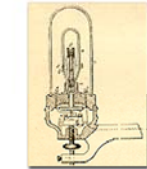
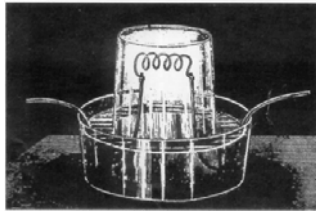
## Early Electric Light Technologies



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# Making Light: Electric Sources

## Early Electric Light Technologies



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

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## Electric Sources: Inventors of the Incandescent



Sir Humphry Davy



James Bowman Lindsay



Warren De La Rue



Alexander Lodygin



Henry Woodward and Matthew Evans



William Sawyer



Lewis Howard Latimer



Heinrich Göbel (AKA Henry Goebel)



Thomas Alva Edison



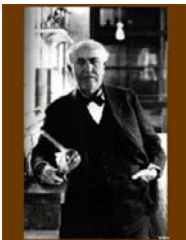
Joseph Swan

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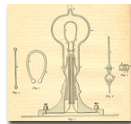
## Early Electric Light Technologies

### 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.



Tungsten filaments were developed by General Electric Co. and M. Coolidge.

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## Light Technologies



### New Developments

There was a need to improve the light several ways:

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

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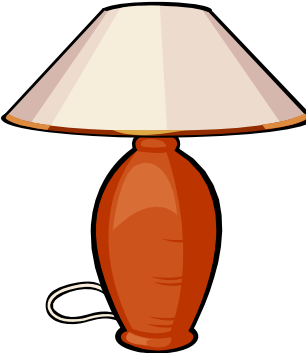
# Making Light: Electric Sources

## What Makes Light: Electric Sources



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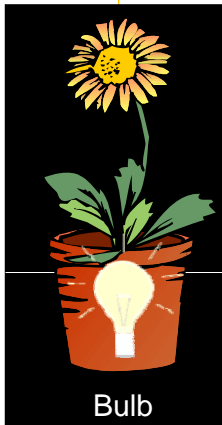
## Electric Sources



Light Fixture

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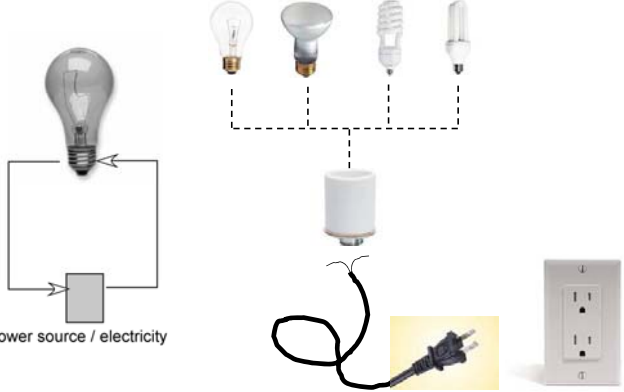
## Electric Sources



Bulb

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## Wiring Basics



power source / electricity

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# Making Light: Electric Sources

## Basic Wiring

SOCKET IS NEUTRAL

HOT CONTACT

NEUTRAL

HOT

NEW POLARIZED PLUG

RIBS OR MARKS ON NEUTRAL WIRE

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## Basic Wiring

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Get directions My places

**Lighting Plus, near Broadway, New York, NY**

Did you mean: Broadway, New York, NY 10032

- Lighting Plus**  
Home Lighting, Furniture and Décor  
No Sales Tax & Free Shipping Deals!  
www.lampspius.com/
- Lighting Plus**  
680 Broadway, New York, NY  
(212) 979-2000  
1 review
- Lighting Plus**  
120% Low Price Guarantee! No Sales Tax and Free Shipping Deals!  
www.lampspius.com/
- Associated Lighting**  
Protecting Buildings in New England  
Family Owned for Three Generations!  
www.alic.com/
- Times Square Lighting NYC**

See all 5,172 results for Lighting Plus.

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Get directions My places

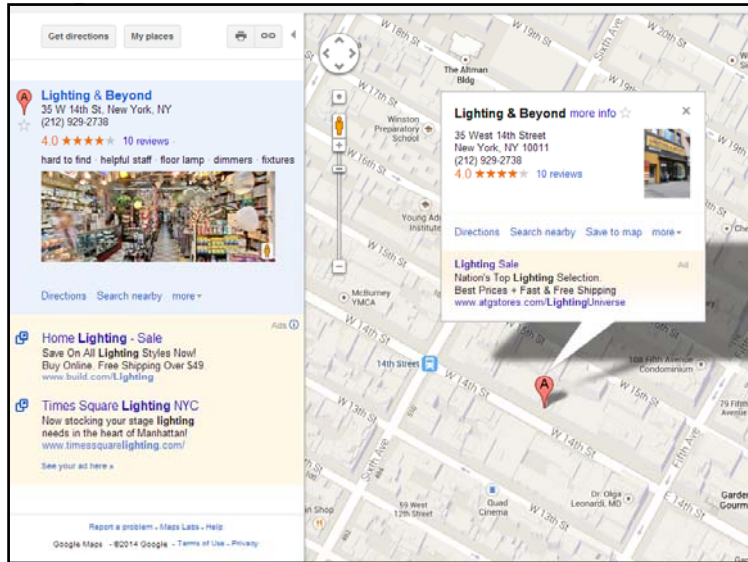
**SL Lighting**  
339 7th Ave, New York, NY  
(212) 268-8505 - slightingnyc.com  
2 reviews

- Lighting Universe**  
Nation's Top Lighting Selection.  
Free Shipping, Lowest Prices!  
www.atgstores.com/LightingUniverse
- Lamps Plus® Official Site**  
1000+ Lighting Items under \$100  
No Sales Tax & Free Shipping Deals!  
www.lampspius.com/

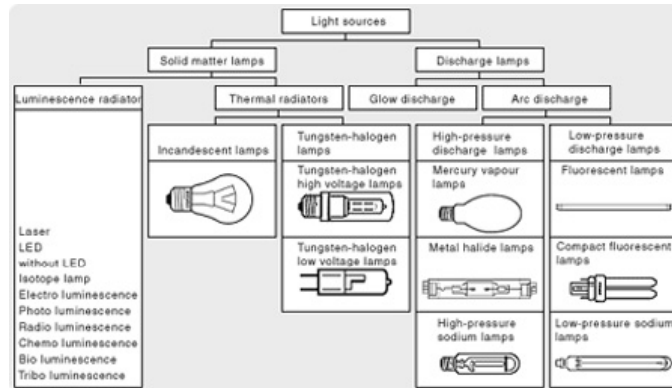
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# Making Light: Electric Sources

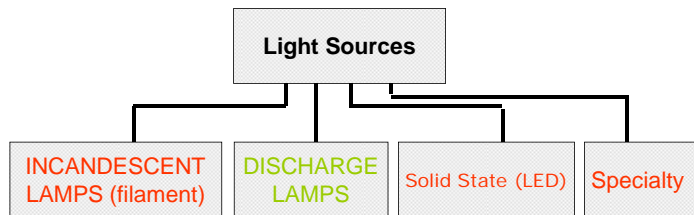


## Electric Sources: Organized by How They Make Light



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## Electric Sources: Organized by How They Make Light



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## Points

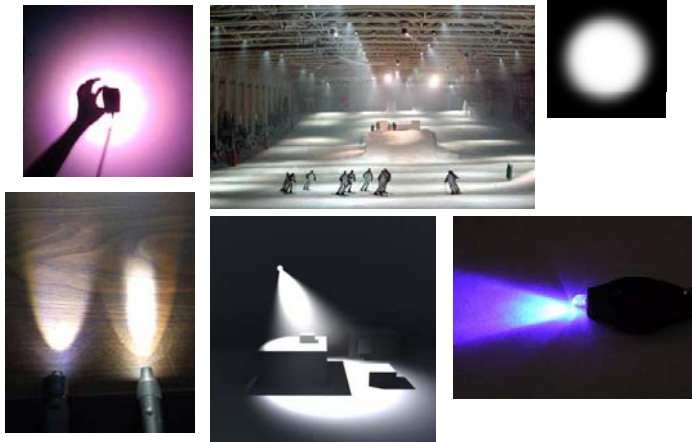


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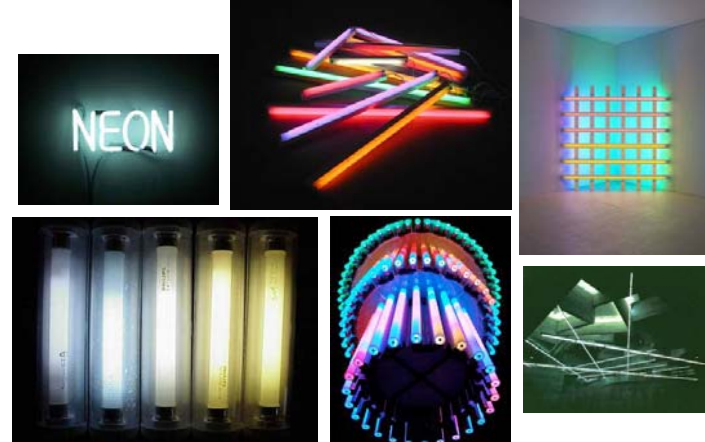
# Making Light: Electric Sources

## Blobs









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## Lines



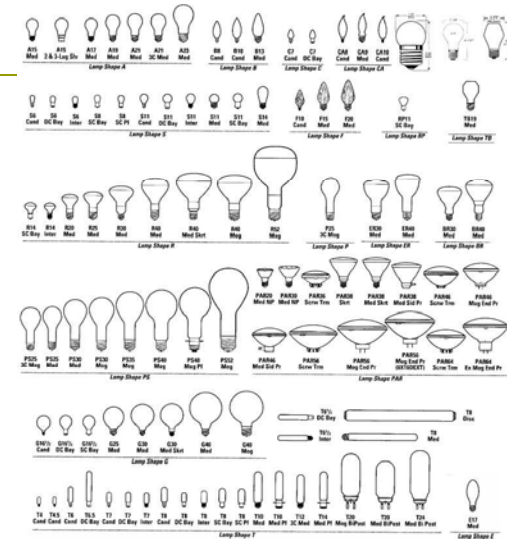
34

## Lamp Shape Nomenclature

GLU/LU	NAME	WATTAGE RANGE	TYPICAL APPLICATION
	Cone	4-7W	Nightlights
	Straight	3-40W	Signs, Decorative, High Intensity, Appliance
	Discor (Short or Topless)	10-100W	Chandeliers and Fixtures with light fixtures
	Flame	10-60W	Decorative light fixtures
	Tubular	6-60W	Aquariums, Appliances, Showcases
	Globe	10-150W	Kitchen, Bath, Decorative Lighting

GLU/LU	NAME	WATTAGE RANGE	TYPICAL APPLICATION
	Fluor Straightback	50-1500W	Most commonly used as Utility or Town-Wire
	Arloway	15-250W	General purpose lighting
	Reflector	30-1000W	Indoor Directional or Down Lighting
	Ellipsoidal Reflector	50-100W	Indoor or Outdoor Down Lighting
	Parabolic Aluminized Reflector	25-500W	Indoor/Outdoor Directional Lighting
	Directional Reflector	40-100W	Indoor Directional or Down Lighting
	Subliminal Reflector	75-150	Indoor Directional or Down Lighting
	Ulobe Tubular	75	Outdoor Pool Lamp Fixtures

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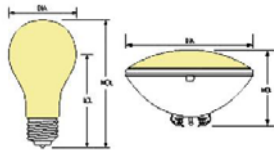


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# Making Light: Electric Sources

## Lamp Shapes

### BULB IDENTIFICATION

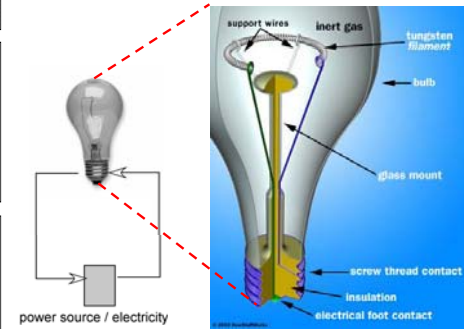


DIA: Diameter of bulb at widest point.  
 MOL: Maximum Overall Length including base or pins.  
 LCL: Distance between the center of the arc tube and the Light Center Length reference plane.  
 Note: Lamp drawings are not drawn to scale. Be sure to check size and dimension information when identifying each lamp.  
 To convert inches to millimeters, multiply the dimension (in inches) by 25.4 (i.e. 1.5" x 25.4 = 38.1 mm)

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## Electric Sources: Organized by How They Make Light

### INCANDESCENT LAMPS (filament)



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## How Halogen Lamps Work



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## Points: Halogen Lamps



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# Making Light: Electric Sources

## “Blob” Source Halogen Lamps



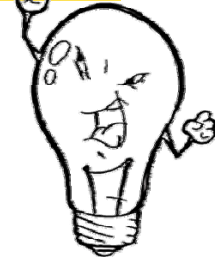
41

## Federal Law is a Performance Standard

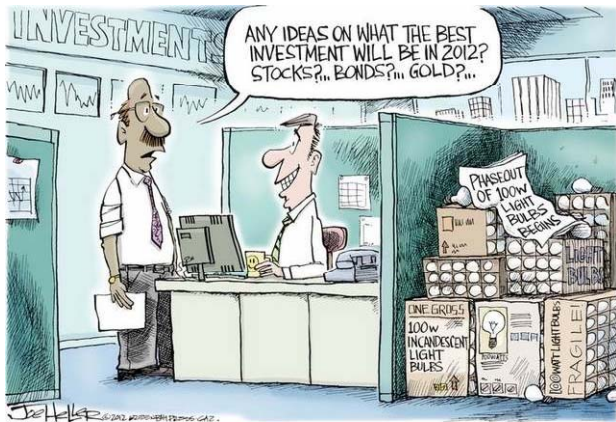
*“The reports of my death are greatly exaggerated”*



The lighting industry prefers to think of the 100-watt A-lamp not as being banished. But, rather retiring at the age of 130 years old.



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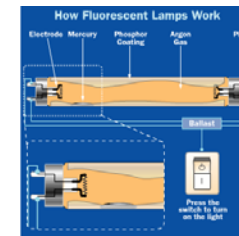
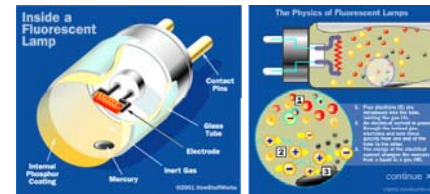
## Electric Sources: Organized by How They Make Light

### DISCHARGE LAMPS

#### Fluorescent Linear



#### Compact



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# Making Light: Electric Sources

## Fluorescent Lamp



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## Fluorescent Lamp

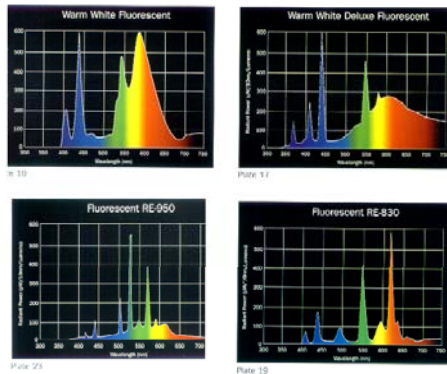
Find a bulb by shape: **FLUORESCENT**



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## Spectral Power Distribution Curves

*Fluorescent*



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

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## How Fluorescent Lamps Work

How Fluorescent Lights Work



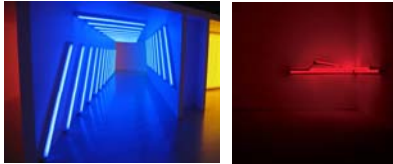
<http://www.youtube.com/watch?v=rS5LC2aH0c4&feature=related>

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# Making Light: Electric Sources

## LIGHT is - *To The Artist*

---



Light



## LIGHT is - *To The Artist*

---



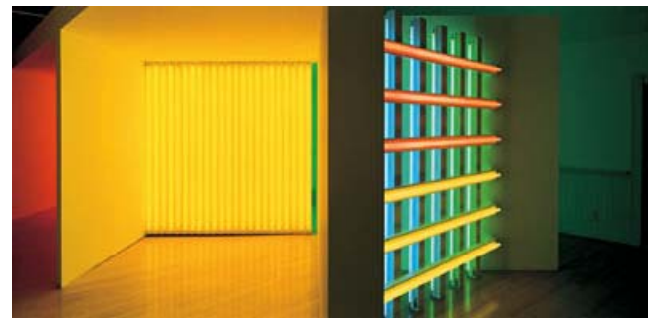
## LIGHT is - *To The Artist*

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## LIGHT is - *To The Artist*

---



# Making Light: Electric Sources

## 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.

Linear Fluorescent

U-Bend Fluorescent

Circline Fluorescent

Compact Fluorescent

HID

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

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## Electric Sources: Organized by How They Make Light

### DISCHARGE LAMPS

#### High Intensity (HID)

### Metal Halide Lamp Technology

This metal halide HID lamp combines mercury and metal halides under high pressure. In the arc stream, these atoms generate both ultraviolet radiation and visible light. A specially formulated glass bulb filters the ultraviolet radiation without affecting the visible light.

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## Electric Sources - Lamps

### Solid State (LED)

#### White

Discrete (monochromatic, variable Kelvin)

#### Color

RGB

#### Tri-node

#### Retrofit

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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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# Making Light: Electric Sources

## How LED's Work

Anatomy of a White Light Emitting Diode

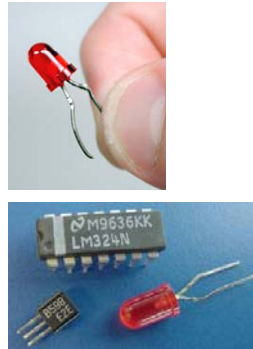
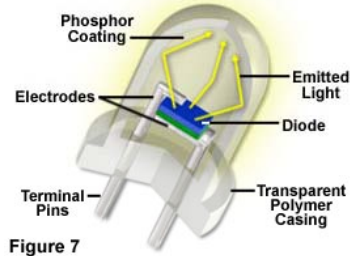
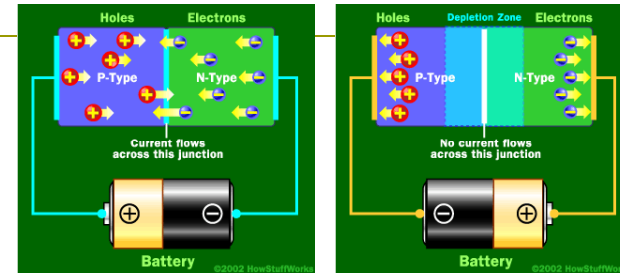
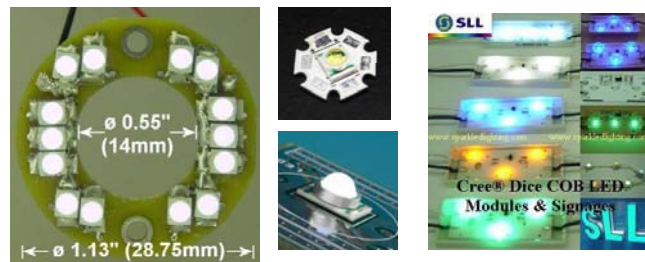


Figure 7



When the negative end of the circuit is hooked up to the N-type layer and the positive end is hooked up to 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!**

# Making Light: Electric Sources

[vc.wmv](#)

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

CONTINUE >

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## LED

Mixture of Light (Color Additive)

### RGB Lighting Systems

Specific-class intelligent LED lighting systems for indoor and outdoor applications in a multitude of sizes and shapes, from wall washing fixtures to cove accents to submersible lighting solutions, complete with controller and power supply options.

Linear Lighting Systems light alcoves and other tight architectural/accents spaces.

- Color Accents Powercore
- Color Cove EC
- Color Cove MK Powercore
- Color Cove NOT
- Color Cove GL

Direct View Systems are designed to be backed at, not to illuminate surfaces.

- Color Flex SL
- Color Flex SLX
- Color Module FX
- Color TM FX 22

Wall Washing Systems project light against surfaces.

- ColorBlast 12
- ColorBlast 12 Powercore
- ColorBlast 12 TR
- ColorBlast 12 TR (V)
- ColorBlast 6
- ColorBlast 8
- ColorCast 14
- C-Splash 2
- Color MR 92

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## LED

### IntelliWhite

Introducing IntelliWhite™, the next milestone in the evolution of intelligent LED lighting. These first-of-their-kind, intelligent illumination systems combine advanced high-brightness white LEDs with Color Kinetics' digital control expertise to enable traditional and completely new uses of high-quality white light. Learn more...

Read more about Color Temperature And LED Lighting and other related white papers.

Color Temperature Controllable

- New IW Blast 12 Powercore
- New IW Cove Powercore
- New IW Cast 14 Powercore
- New IW Profile g2

Products to be Replaced - click on images below to learn about replacement products

- IW Blast 12
- IW MR
- IW Profile

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## LED

<http://www.colorkinetics.com/showcase/videos/target.htm>

[http://www.colorkinetics.com/showcase/videos/wf\\_04.htm](http://www.colorkinetics.com/showcase/videos/wf_04.htm)

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# Making Light: Electric Sources

## LED



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

65

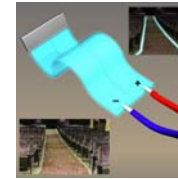
## Electric Sources - Lamps

### Specialty

#### Neon



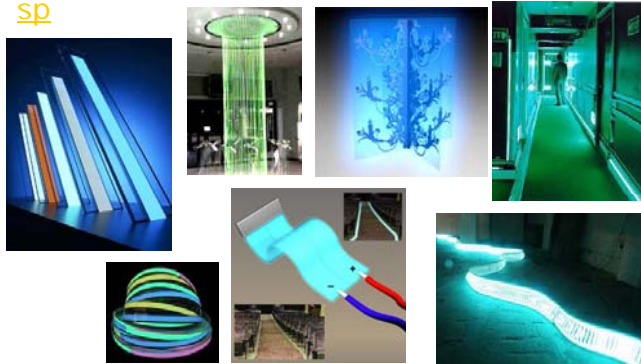
#### Electroluminescent



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## Electroluminescent

□ <http://www.ceelite.com/products/lamps.asp>



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# Making Light: Electric Sources

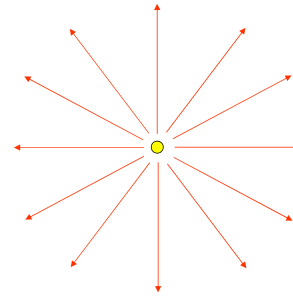
## Optical Properties of Light

- Light Travels in a Straight Line
- Light Bounces and Reflects
- Light Refracts and Bends
- Light is Comprised of Many Colors

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## Light Direction

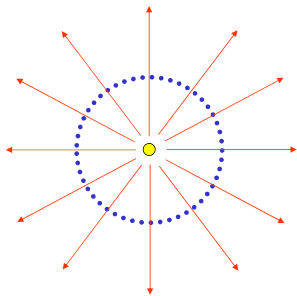
Light travels in a straight line...radiates out from the source



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## Light Direction of Clear Lamps

Light travels in a straight line...radiates out from the source

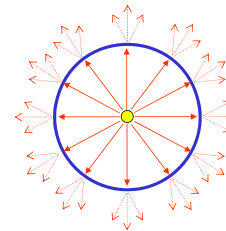


.... add a clear enclosure or envelope around the source, the light will still travel in a straight line.

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## Light Direction of Frosted Lamps

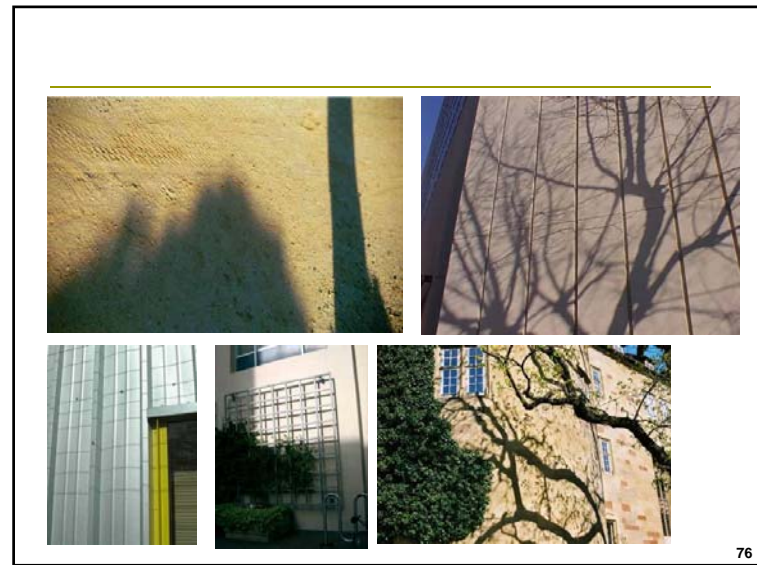
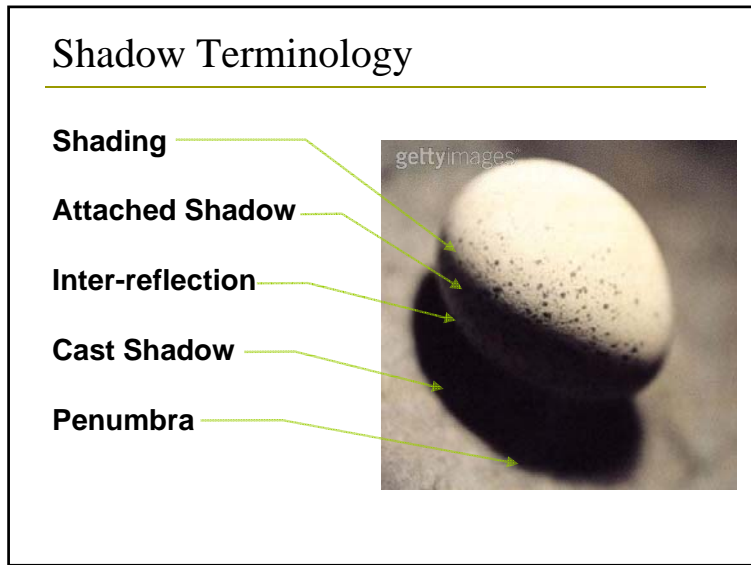
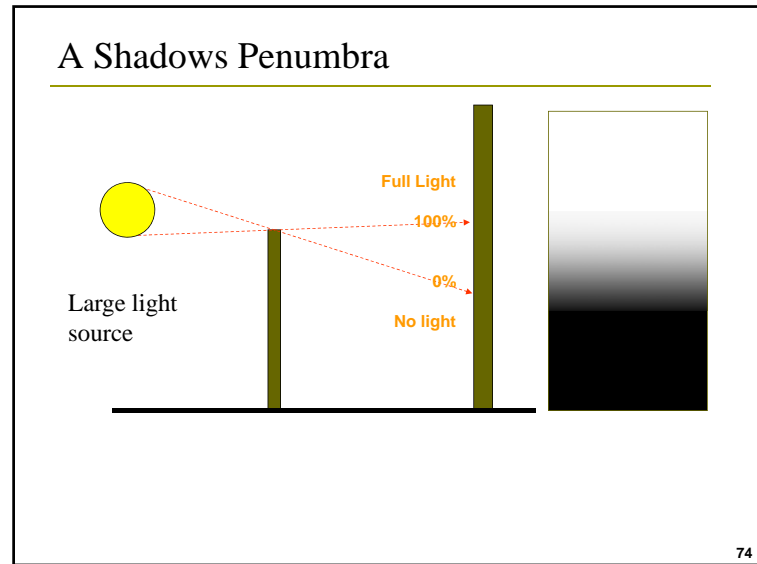
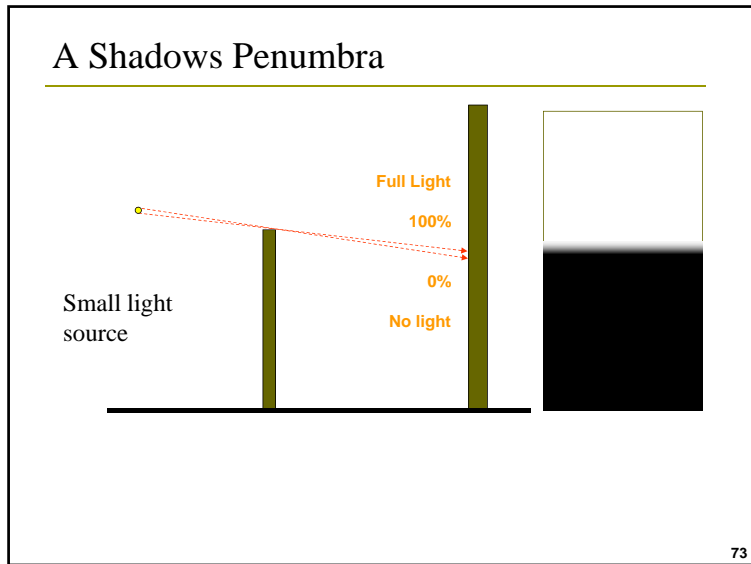
Light travels in a straight line...radiates out from the source



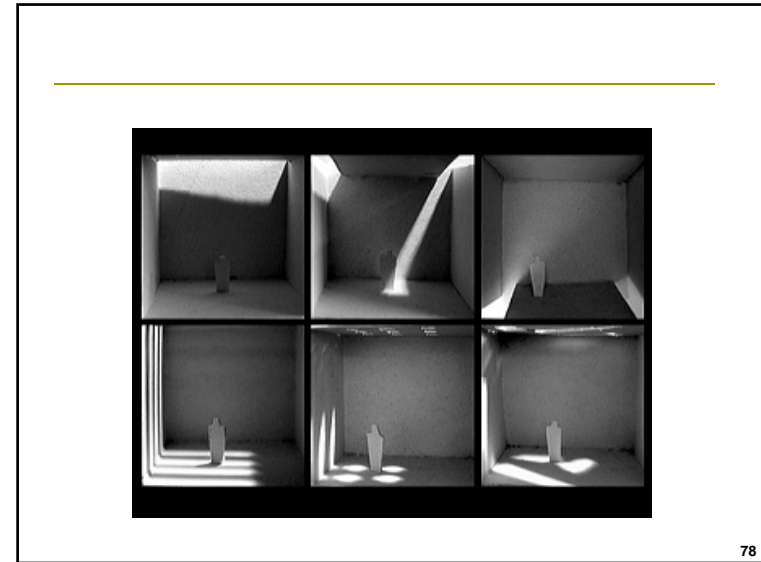
.... add a coated or frosted enclosure or envelope around the source, the direction of light will bend and radiate from the surface of the enclosure

72

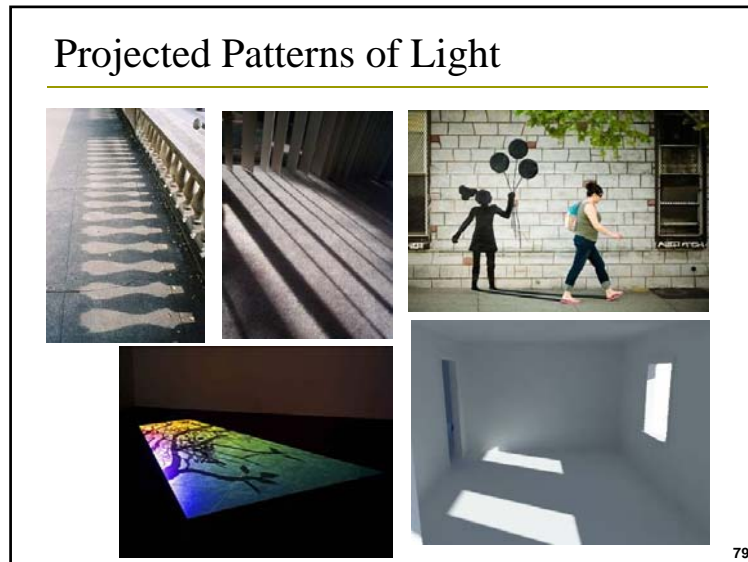
# Making Light: Electric Sources



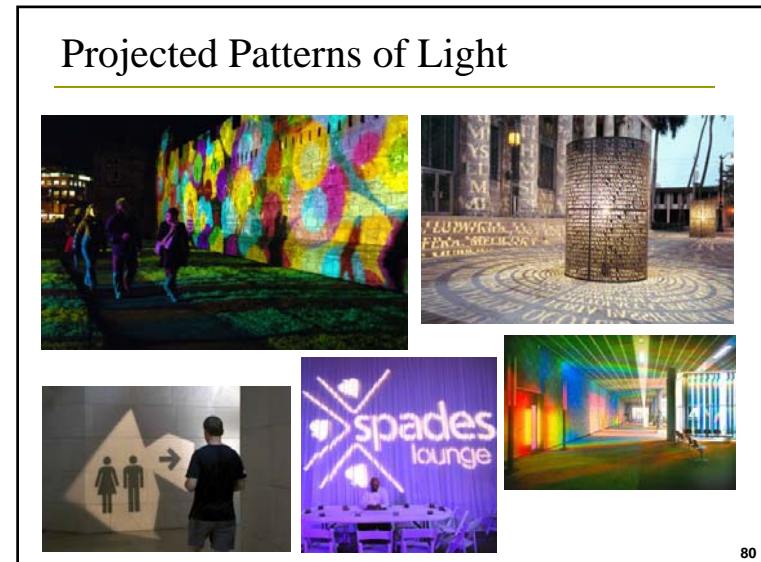
# Making Light: Electric Sources



## Projected Patterns of Light

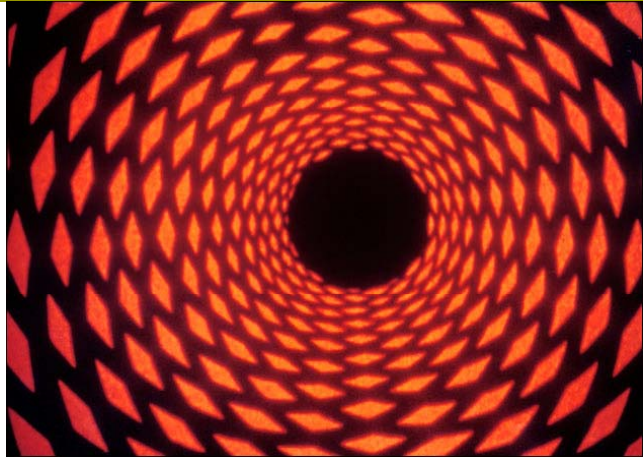


## Projected Patterns of Light

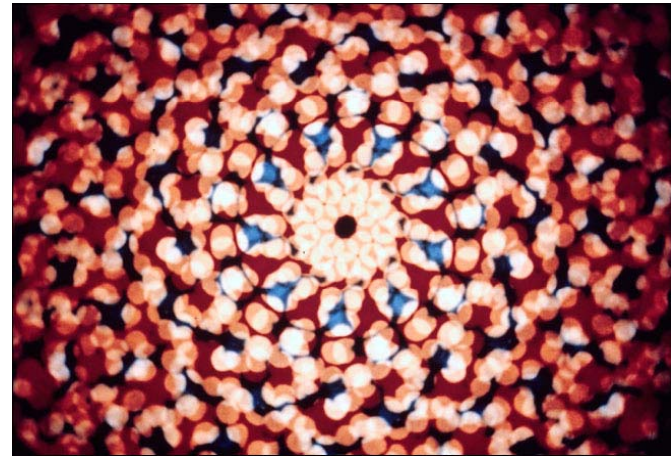


# Making Light: Electric Sources

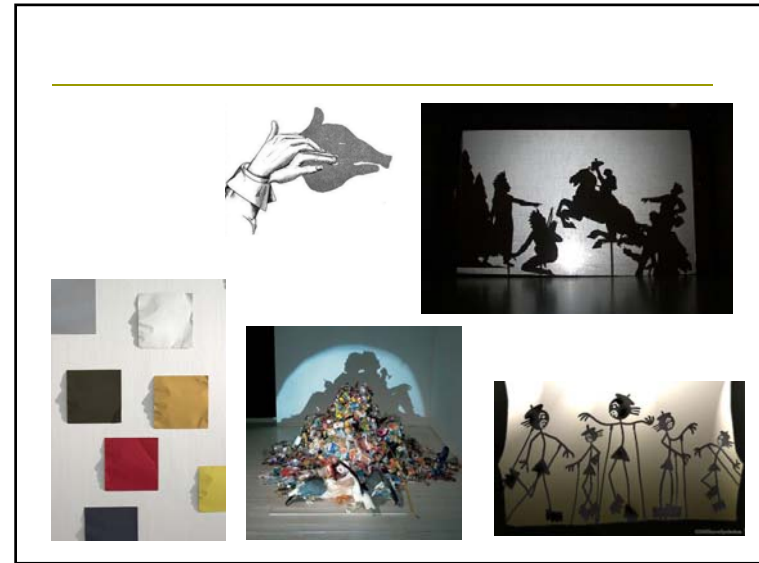
LIGHT is - *To The Artist*



LIGHT is - *To The Artist*

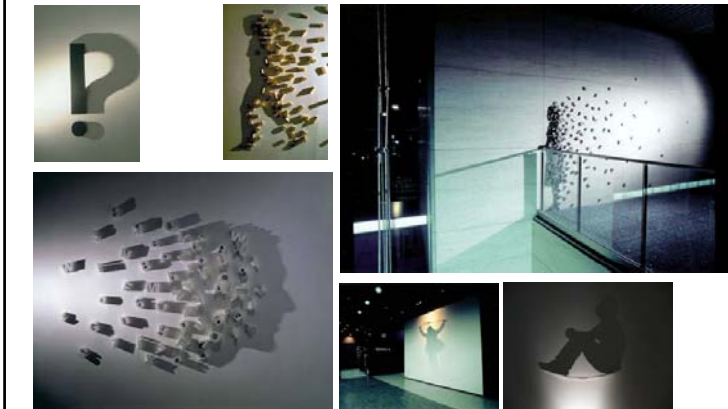


LIGHT is - *To The Artist*



# Making Light: Electric Sources

*Kumi Yamashita*

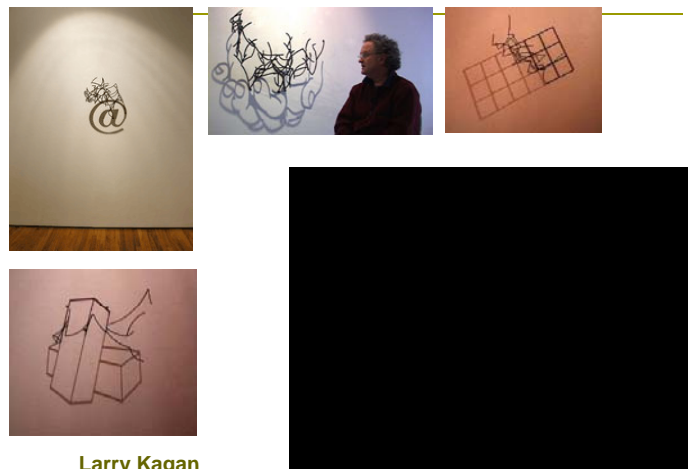


85

*Fabrizio Corneli*

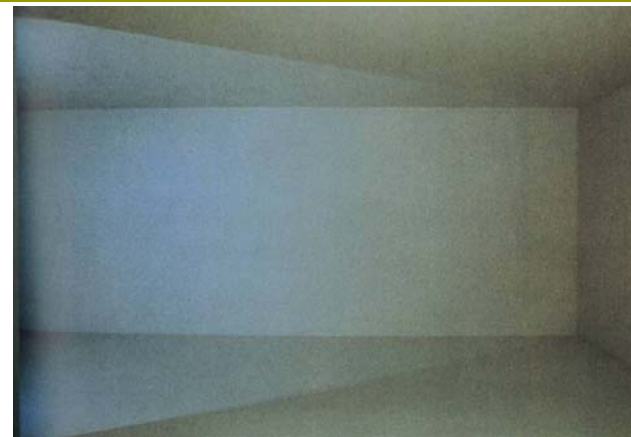


86



Larry Kagan

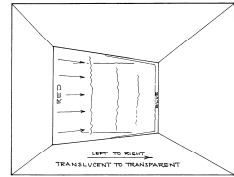
*James Turrell "Wedgework"*



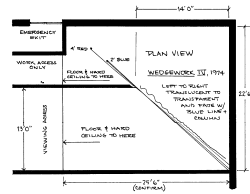
88

# Making Light: Electric Sources

James Turrell "Wedgework"

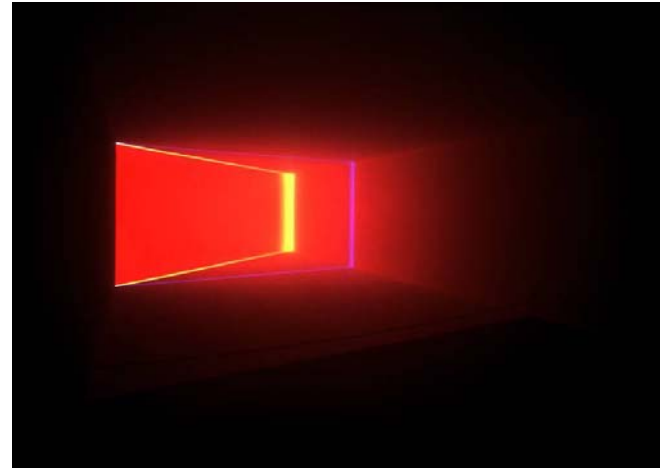


WEDGECORE III, 1979 THE WEDGECORE  
 TWO FRONT LIGHTS, ONE WITH BLUE, BLUE  
 LIGHT AND GREEN. OTHERS TO LIGHT LEFT  
 TO RIGHT, GOES TO TRANSPARENT



89

James Turrell

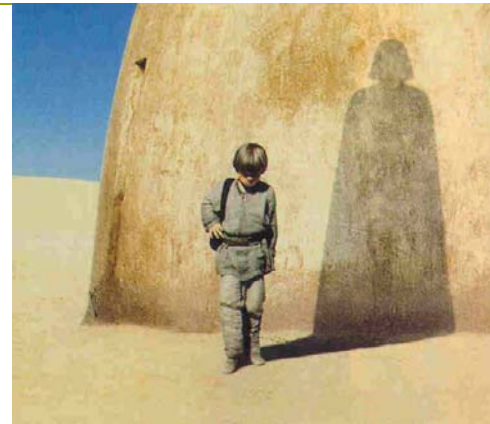


90

Famous Shadows



Famous Shadows



# Making Light: Electric Sources

## Famous Shadows



## Famous Shadows



## Grazing Effect



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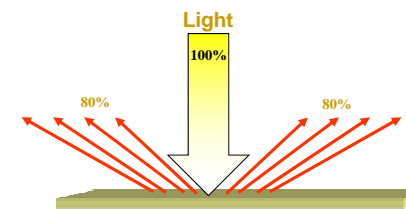
## Reflected Light

### □ Optics

- Absorption
- Reflection

The material absorbs 20%  
- reflects 80%

Typical Materials:  
Metal  
Mirror  
Wood



96



# Making Light: Electric Sources

## Shadow Terminology

Shading

Shading

Highlight

Diffuse

Glossy

## Reflection

Light Source

Incidence

Reflection

Incidence = the light that enters

Reflection = the light that exits

- For "specular" reflectors, the angle of incidence equals the angle of reflection

98

## Reflected Light

- Luminaires can shape light by reflection
- Reflectors finishes may be
  - Specular – *shiny, polished*
  - Semi-Specular
  - Diffuse – *dull, matte*

Equal Angles of Reflection

Angle of Incidence

Angle of Reflection

Figure 1

Light Source

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## Reflected Light

- Luminaires can shape light by reflection
- Reflectors may be
  - Specular – *shiny, polished*
  - Semi-Specular
  - Diffuse – *dull, matte*

Specular and Diffuse Reflection

Specular Reflection

Diffuse Reflection

Figure 2

Light Source

100

# Making Light: Electric Sources

## Reflector Contours

### Parabolic

Reflection from Concave and Convex Mirrors

Center of Focal Curvature  
Virtual Focal Point  
Center of Image Point Curvature

Object Image Concave Mirror Figure 4  
Convex Mirror Figure 3

Reflection Rays are Parallel

Parabola or Parabolic Reflector  
Typically Specular Finish

101

## Reflector Contours

### Ellipsoidal

Rays converge  
2 foci

Ellipse, Ellipsoidal, or Elliptical Reflector  
Typically Specular Finish

102

## Reflector Contours

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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## Refracted Light

- Optics
  - Absorption
  - Transmission

The material absorbs 20% - transmits 80%

Typical Materials:  
Glass  
Plastic  
Fabric

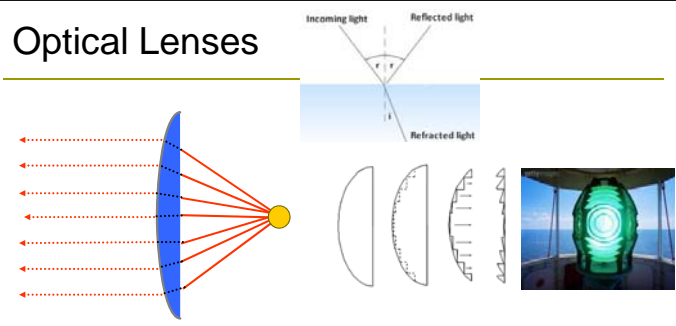
Light 100%

80% 80%

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# Making Light: Electric Sources

## Optical Lenses



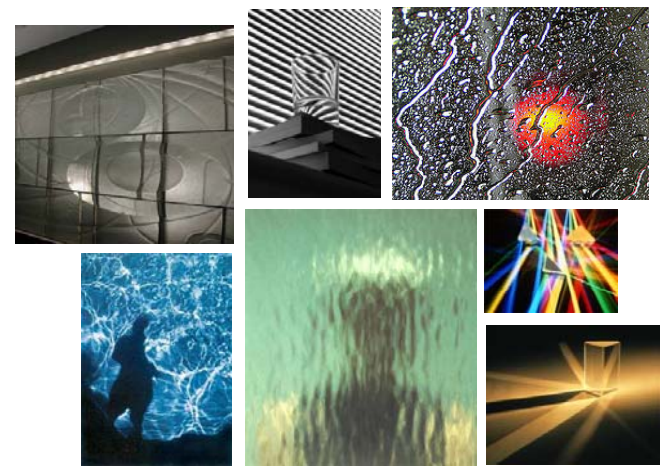
The diagram shows a plano-convex lens on the left with parallel light rays (red dashed lines) entering from the left and converging to a focal point (yellow dot). To the right, a Fresnel lens is shown as a series of flattened plano-convex lenses. Above it, a diagram illustrates light rays (labeled 'Incoming light' and 'Reflected light') hitting a surface and being refracted into a parallel beam (labeled 'Refracted light'). Below the Fresnel lens diagram is a photograph of a large, green, multi-faceted Fresnel lens.

Plano-Convex: diverging rays are refracted to make a parallel beam

Fresnel: Flattened Plano-Convex lens

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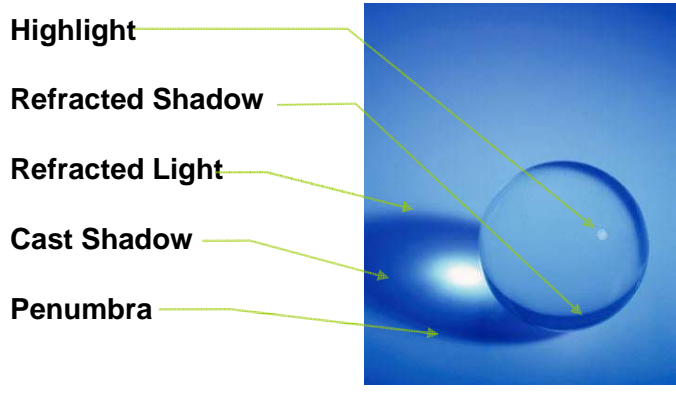
## Refracted Light



A collage of six images illustrating light refraction and dispersion. Top left: A large, curved glass structure. Top middle: A close-up of a glass pane with light rays. Top right: A colorful, multi-colored light pattern. Bottom left: A silhouette of a person looking through a blue, refractive medium. Bottom middle: A green, multi-colored light pattern. Bottom right: A glass prism dispersing light into a spectrum.

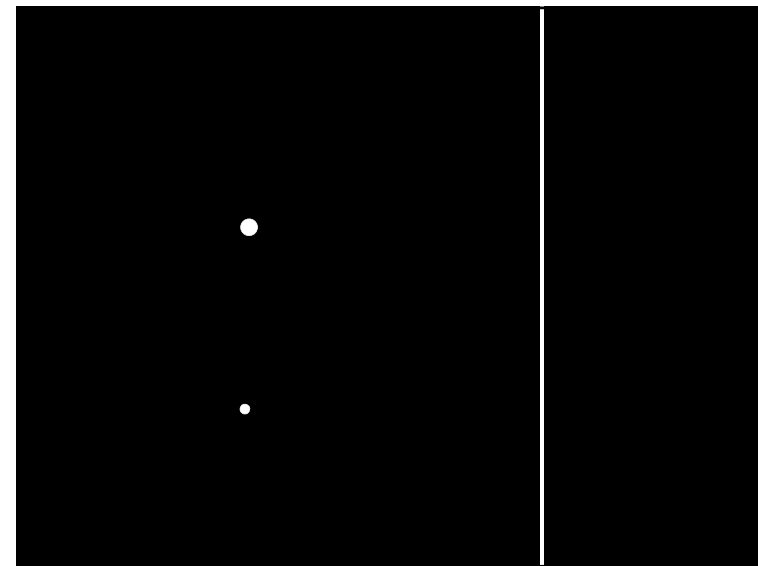
106

## Shadow Terminology



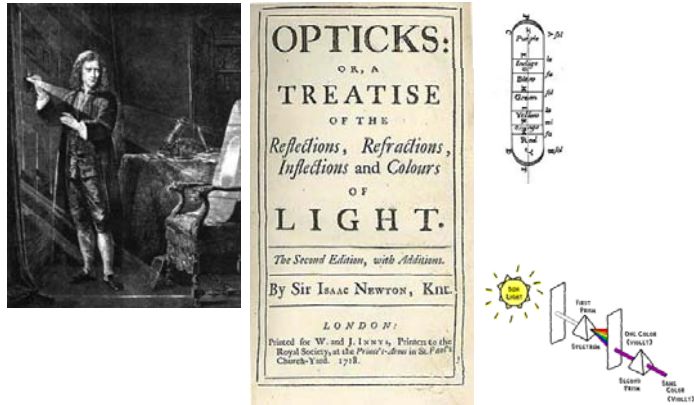
The diagram shows a blue sphere on a blue surface. Labels with arrows point to different parts of the sphere and its shadow:

- Highlight**: The bright spot on the top of the sphere.
- Refracted Shadow**: The shadow cast by the sphere onto the surface.
- Refracted Light**: The light rays passing through the sphere.
- Cast Shadow**: The shadow cast by the sphere onto the surface.
- Penumbra**: The soft, outer edge of the shadow.



# Making Light: Electric Sources

## Controlling Light



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## What is Light?

**Light** is a form of energy that is part of the electromagnetic spectrum visible to the human eye.

### The Light Spectrum

Light waves of a specific energy level will emit a particular color.

Sir Isaac Newton recognized the visible light spectrum in 1666, and he identified seven colors: red, orange, yellow, green, blue, indigo, and violet.

Newton's colors are arbitrary segments of the continuous spectrum of color.

When all of the spectral colors travel together, they combine to make white light.

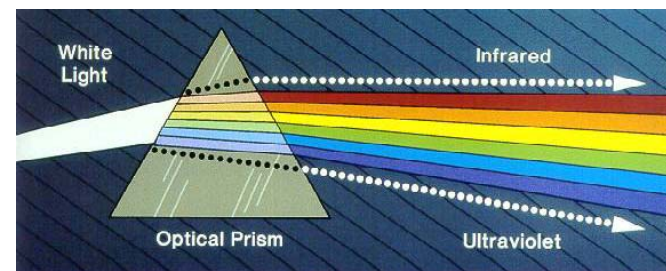
110

## Light = Color



111

## Light = Color



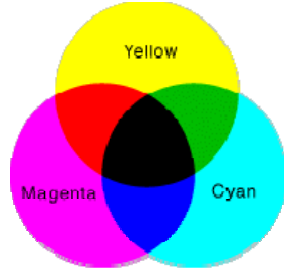
112

# Making Light: Electric Sources

Light = Color



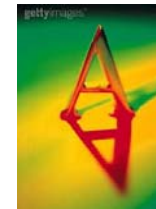
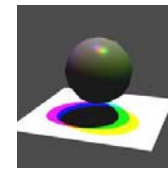
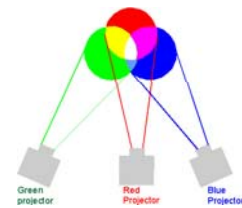
Colors by Addition  
Mixture of Light



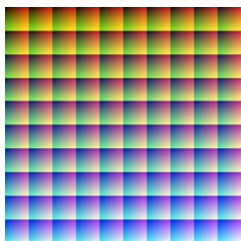
Colors by Subtraction  
Mixture of Pigments

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Color Mixing

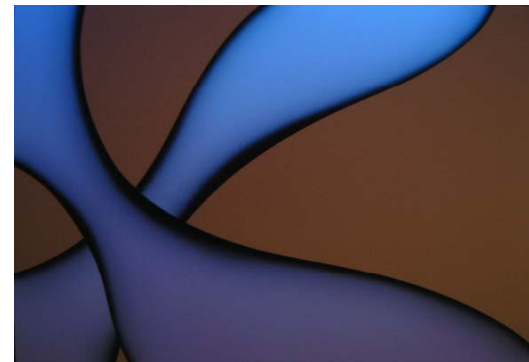


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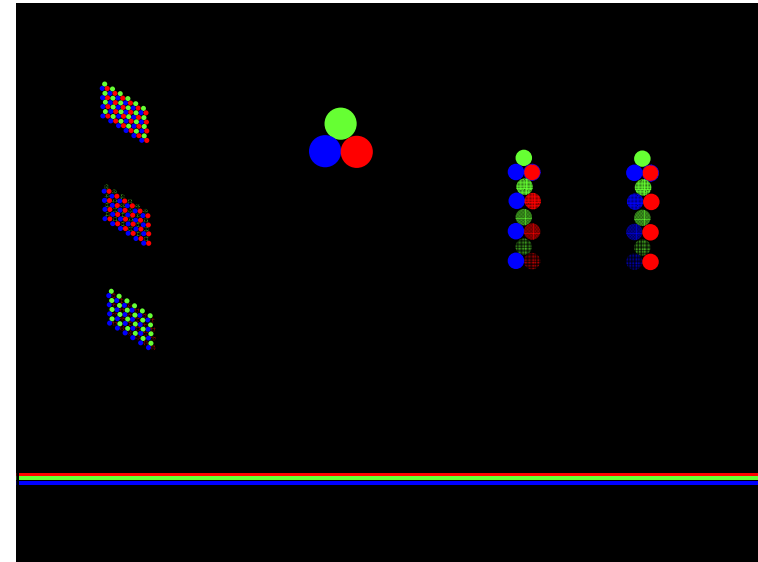
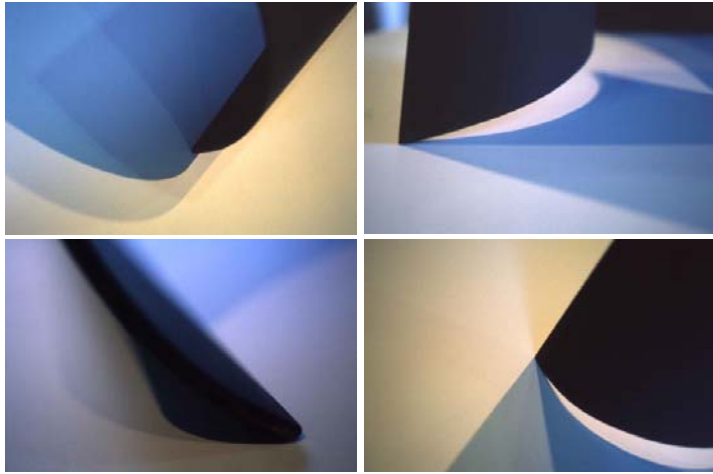
LIGHT is - *To The Artist*



Rufus Knightwebb

# Making Light: Electric Sources

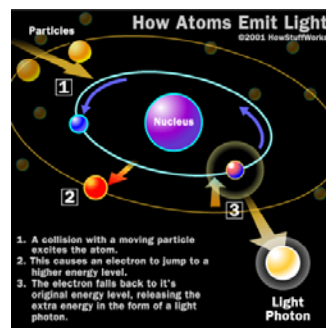
**LIGHT** is – *To The Photographer*



## What is Light?

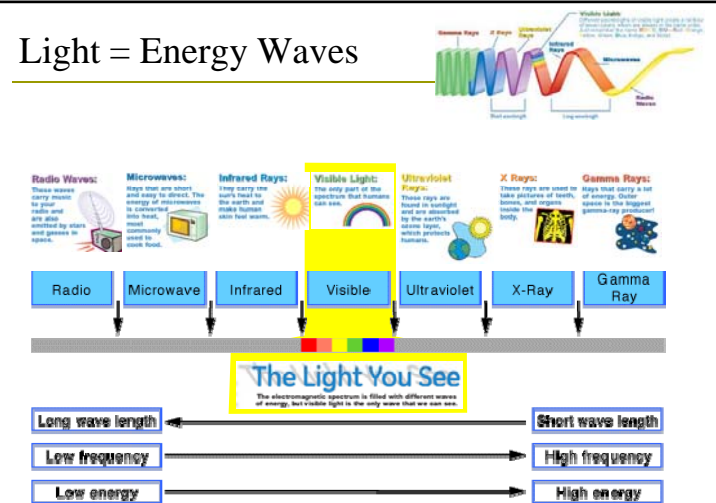
There are two different ways of talking about light:

- There is the "particle" theory, expressed in part by the word **photon**.
- There is the "wave" theory, expressed by the term **light wave**.



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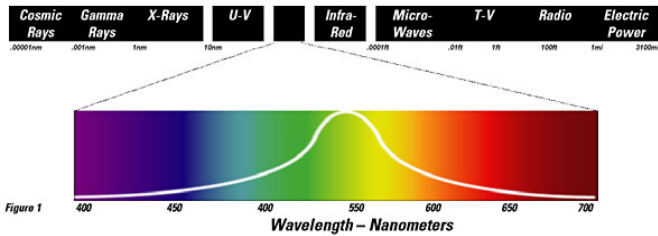
## Light = Energy Waves



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# Making Light: Electric Sources

## Light = Color

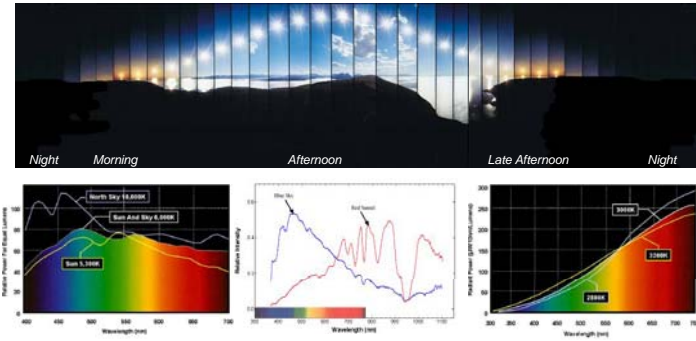


**The Light You See**  
The electromagnetic spectrum is filled with different waves of energy, but visible light is the only wave that we can see.

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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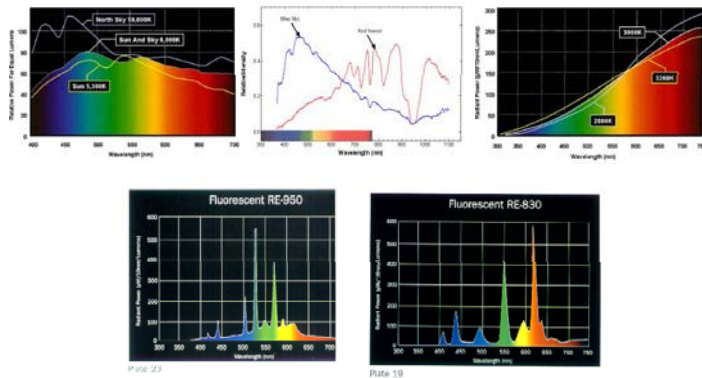
## Color Spectrum



Incandescent Lamps and Natural Daylight produce smooth, continuous spectra.

122

## Color Spectrum



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

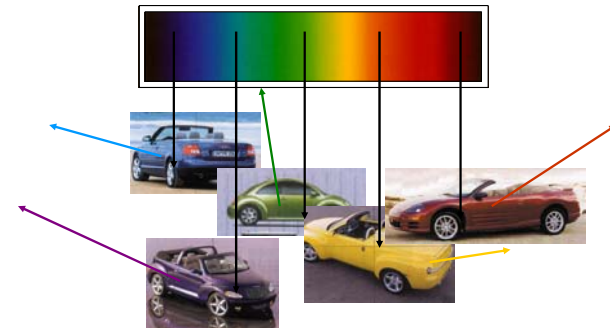
123

## Color Rendering Index

*how a light source renders the color of objects*

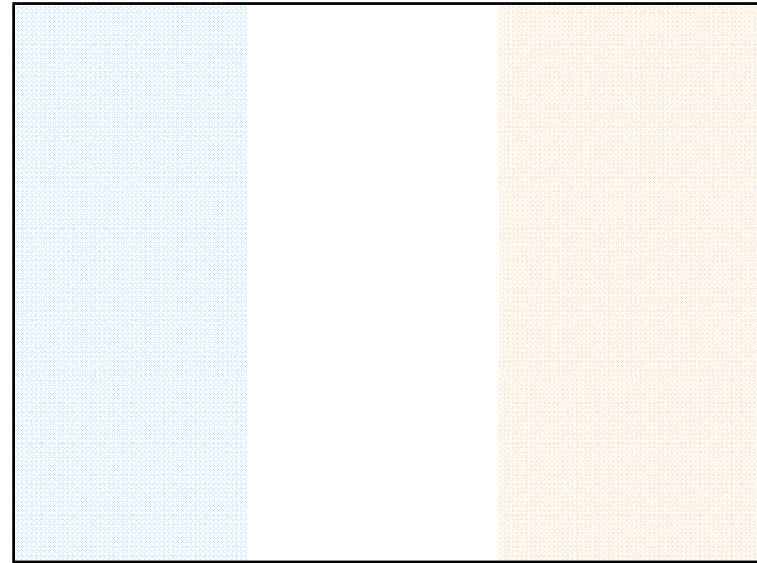
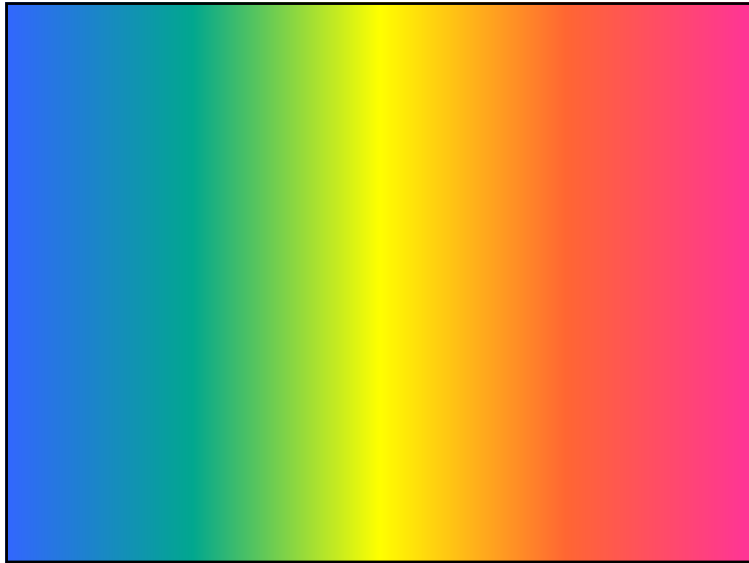
**High CRI** light makes virtually all colors look natural and vibrant.

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

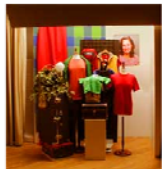


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# Making Light: Electric Sources



## Seeing Color



Incandescent / Halogen



CE Cool White



Ceramic Metal Halide



SP30



SP36



HPS

[http://www.gelighting.com/na/business\\_lighting/education\\_resources/learn\\_about\\_light/color\\_lamp.htm](http://www.gelighting.com/na/business_lighting/education_resources/learn_about_light/color_lamp.htm)

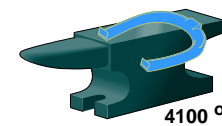
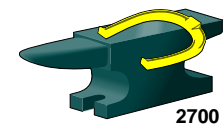
127

## Correlated Color Temperature

*color appearance of various light sources*

The higher the color temperature (CCT), the **“cooler”** the color of the lamp is in appearance.

The lower the color temperature (CCT) the **“warmer”** the color the lamp is in appearance.



Color Temperature of a Black-Body Radiator



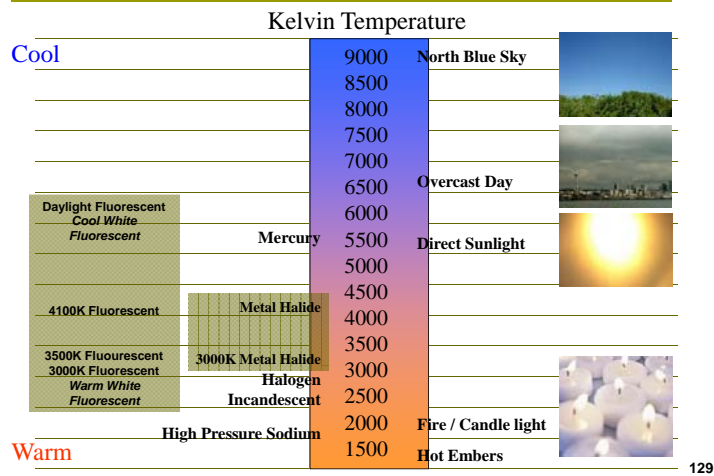
**This color temperature is measured in Kelvin.**

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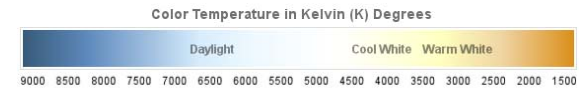
# Making Light: Electric Sources

## Correlated Color Temperature



## Correlated Color Temperature

color appearance of various light sources



How does Color Temperature affect the appearance of a room?



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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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*“Change a bulb and save the world!”*




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# Making Light: Electric Sources

**Electricity Cost**  
(for 800-900 lumens at a rate of \$0.10 per kWh)

  $(60 \text{ watts}) \times (8000 \text{ hours}) \times \left( \frac{\$0.10}{1000 \text{ watt} \cdot \text{hours}} \right) = \$48$


  $(14 \text{ watts}) \times (8000 \text{ hours}) \times \left( \frac{\$0.10}{1000 \text{ watt} \cdot \text{hours}} \right) = \$11.20$

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# The Green Police

**Audi 2010 Green Car Super Bowl Commercial**

**GREEN POLICE** 1 video Subscribe



[http://www.youtube.com/watch?v=Wq58zS4\\_jvM](http://www.youtube.com/watch?v=Wq58zS4_jvM)

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# Fluorescent Systems

*Incandescent lamps are a simple thing. A bit of wire that gets very hot. It presents a very simple, resistive load to the electricity supply.*

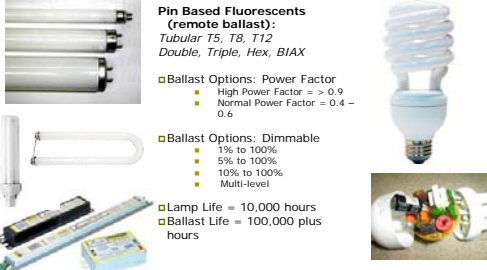
*Fluorescents on the other hand is much more complex. The electronics required to make these lamps work present what is known as a reactive load. A ballast is required to operate the source, but the power required to operate the ballast may not be efficient.*

**Pin Based Fluorescents (remote ballast):**  
Tubular T5, T8, T12  
Double, Triple, Hex, BIAx

- Ballast Options: Power Factor
  - High Power Factor = > 0.9
  - Normal Power Factor = 0.4 - 0.6
- Ballast Options: Dimmable
  - 1% to 100%
  - 5% to 100%
  - 10% to 100%
  - Multi-level
- Lamp Life = 10,000 hours
- Ballast Life = 100,000 plus hours



**Screw Fluorescents (integral ballast):**  
Medium base Compact Fluorescent  
Candelabra base Compact Fluorescent

- Ballast Options: Power Factor
  - Normal Power Factor = 0.4
- Ballast Options: Dimmable
  - Range Not Known
- Life = 5,000



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# Lamp Pros and Cons

	<ul style="list-style-type: none"> <li>• Poor spectrum, poor color, poor rendering (CRI = 90-90)</li> <li>• Screw base difficult to dim ("dims to greenish brown color..."), pin base requires special ballast and control</li> <li>• Long Life (limited to 3-hour on cycle)</li> <li>• High efficacy rating (lumen/watt)</li> <li>• Cannot replace point source bulbs in point-source fixtures, Cannot replace all 1000+ incandescent bulb types</li> <li>• Contains toxic mercury (if incandescent is banned, 50,000 lbs of mercury will be introduced into landfills upon disposal every 7 to 10 years)</li> <li>• High embodied energy (several times that of incandescent), most are made in China, which uses coal fired methyl mercury producing power plants</li> <li>• Customer Dissatisfaction: limit uses, high initial cost; high failure rate (many fail after 2 to 20 hours)</li> </ul>	
		<ul style="list-style-type: none"> <li>□ Excellent color, reliable, highest color rendering (CRI = 100)</li> <li>□ Dims easily without specialized equipment.</li> <li>□ Dimming extends life and energy consumption.</li> <li>□ Halogen vs incandescent are 30% more efficient, approach CFL efficiency with controls and best fluorescents in many categories.</li> <li>□ Do not have negative disposal impacts, fully recyclable</li> <li>□ More efficient to produce, i.e., less embodied energy</li> </ul>

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# Making Light: Electric Sources

## What is inside the lamp



- |   |   |
|---|---|
| <ol style="list-style-type: none"> <li>1. glass</li> <li>2. steel</li> <li>3. a small amount of high temperature plastic insulation</li> <li>4. (lead free?) solder</li> <li>5. plating material for exposed metal, probably nickel</li> <li>6. phosphors **</li> <li>7. mercury + mercury vapor **</li> <li>8. silicon (in ICs, transistors, MOSFETs, diodes, etc.)</li> <li>9. fiberglass and epoxy resins (PCB, semiconductor cases)</li> <li>10. aluminum (electrolytic capacitor)</li> <li>11. various plastics (main housing, film capacitors)</li> <li>12. ferrites / ceramics (resistor bodies, choke cores)</li> <li>13. copper wire and PCB traces</li> </ol> | <ol style="list-style-type: none"> <li>1. glass</li> <li>2. steel</li> <li>3. a small amount of high temperature plastic insulation</li> <li>4. (lead free?) solder</li> <li>5. plating material for exposed metal, probably nickel</li> <li>6. tungsten</li> <li>7. inert (and naturally occurring) gas</li> </ol> |
|---|---|

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

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## Screw it Where?

Most screw base CFL packaging states that the lamps must not be used in fully enclosed light fittings. The reason is temperature. Because of the electronic circuitry, all CFLs can only be used where they have reasonable ventilation to prevent overheating. (Excess heat doesn't bother an incandescent lamp, and temperatures well in excess of 100°C won't cause them any problems at all.)



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## \$2,000 Clean-Up Bill

Many people would have seen the story circulating the Net about a woman in Maine (US) who broke a CFL in her daughter's bedroom, and was quoted \$2,000 to clean up the mercury.

Yes, mercury is a potent neurotoxin, but metallic mercury is relatively safe. The real danger comes from the vapor and various salts and compounds (as may easily be created in landfill for example) ... not from 5mg of mercury buried in the carpet.

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### 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:

1. Open a window and leave the room for 15 minutes or more.
2. 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.
3. 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.
4. 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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# Making Light: Electric Sources

## How Florescent Lamps are Recycled

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### Step 1

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



### Step 3

- In feed to the process consists of manually opening the packaged containers and placing the lamps into the feed mechanism. The lamps are conveyed into a chamber where a breaker performs an initial particle size reduction of the lamps.
- Broken lamp pieces are then crushed to achieve a greater particle size reduction and transferred to a primary separator to separate the larger components (aluminum end 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 88% 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 reorted to reclaim mercury.



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## Lamp Manufactures


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**Philips**  
[www.lighting.philips.com](http://www.lighting.philips.com)



**Osram/Sylvania**  
[www.sylvania.com](http://www.sylvania.com)



Others

**Venture Lighting**  
<http://www.venturelighting.com/>



**Ushio America Inc**  
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