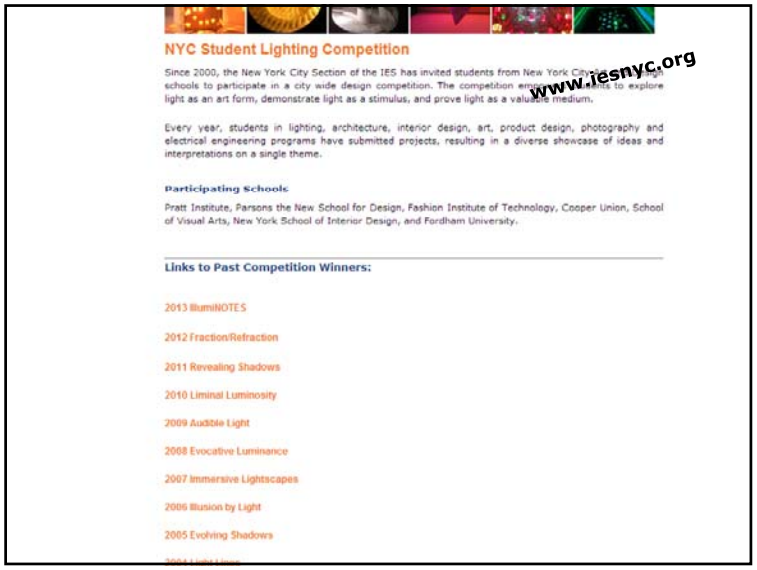
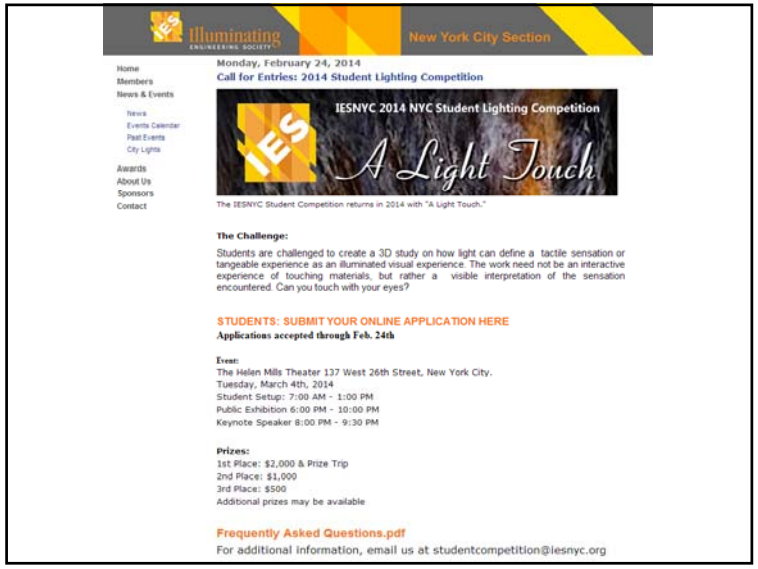
Making Light: Electric Sources





Applications accepted online through
Monday, Feb. 24th

Tuesday, March 4th, 2014
The Helen Mills Theater 137 West 26th

Student Setup: 7:00 AM - 1:00 PM

Public Exhibition 6:00 PM - 10:00 PM
Keynote Speaker 8:00 PM - 9:30 PM

Making Light: Electric Sources

Illuminating ENGINEERING SOCIETY

NEW YORK CITY SECTION
536 LaGuardia Place
New York, New York 10012
212.933.6460
www.iesnyc.org

FREQUENTLY ASKED QUESTIONS

1. I live out of New York City. May I submit?
Eligibility is for students attending a design college or university located in New York City (Manhattan, Brooklyn, Bronx, Queens, and Staten Island) or the New York counties (Columbia, Dutchess, Green, Orange, Putnam, Rockland, Sullivan, Ulster, Westchester) of the former Mid-Hudson Section.

2. Can teams of students submit one submission?
Yes. When submitting your application please list one student name as the primary contact, and indicate the other students names in the "Note or Comment" 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 read 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 closed 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 yours goes weak or loses power.

7. Are candles allowed?
No. No candles or open flames 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.

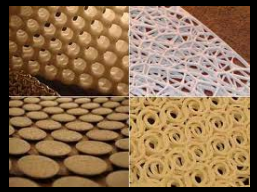
NEW YORK CITY SECTION
536 LaGuardia Place
New York, New York 10012
212.933.6460
www.iesnyc.org

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?

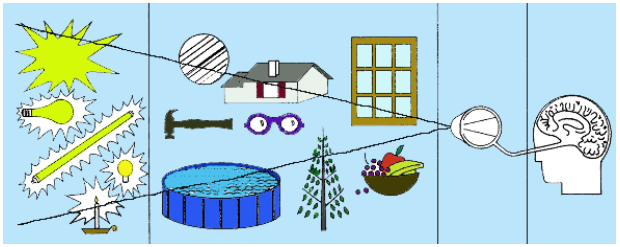
The challenge is to interpret and express the theme in the form of an abstract 3-dimensional lighting experience constructed of your choice of materials. Since the object need not be interactive, what visual effect can you create imply a tactile experience?



Making Light: Electric Sources

Visual System

Light Sources	Secondary Light Sources	Eyes	Brain
Generators – Transmitters	Modifiers and Re-transmitters	Receivers – Encoders	Decoder – Interpreter



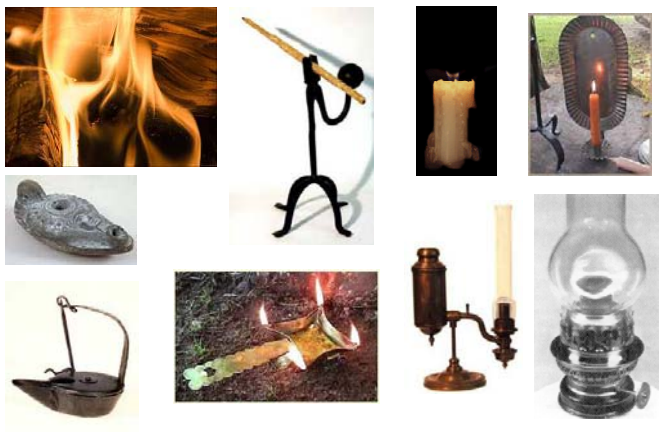
Sun, Discharge lamps, fluorescent lamps. Incandescent lamps, Open flames, etc.	Atmosphere, Air, Water, Planets, Lenses, Windows, Tress – All natural or manufactured objects which modify light waves before they reach the eye.	Cornea, Iris, Lens, Rods & Cones, Optic Nerves	Analysis, Identification Association Perception

10

What Makes Light: The Sun

11

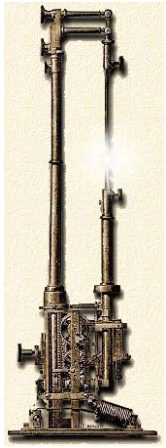
What Makes Light: Fire

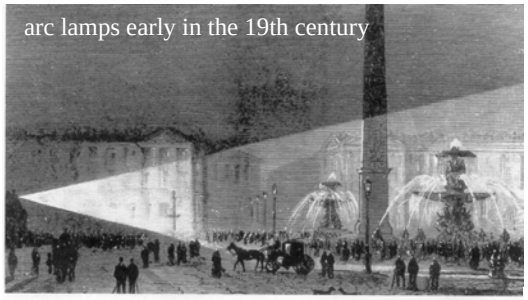


12

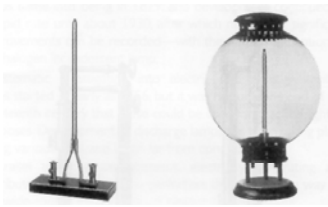
Making Light: Electric Sources

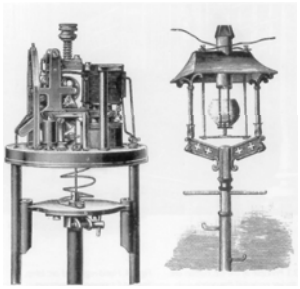
Early Electric Light Technologies

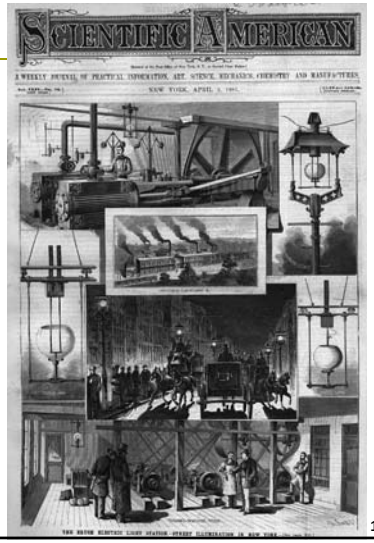




13

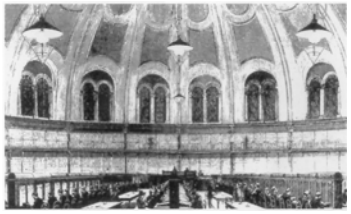


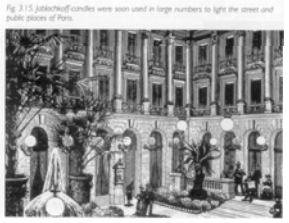




14

Early Electric Light Technologies





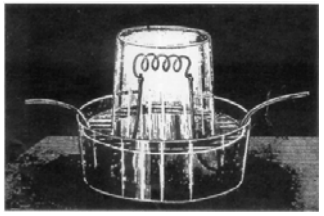
15

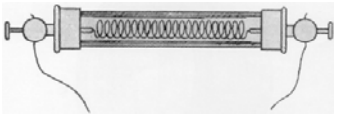
Early Electric Light Technologies

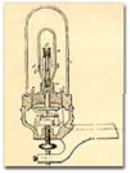
16

Making Light: Electric Sources

Early Electric Light Technologies







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

17

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

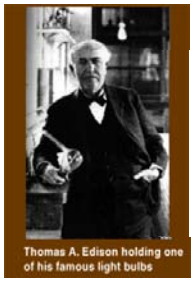
Joseph Swan

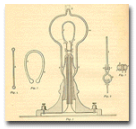
18

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.

19

Light Technologies

New Developments

There was a need to improve the light several ways:

1. The need for a constant flame, which could me 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

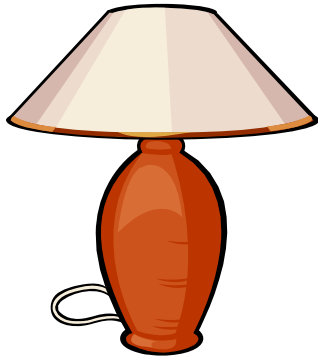
20

Making Light: Electric Sources

What Makes Light: Electric Sources

21

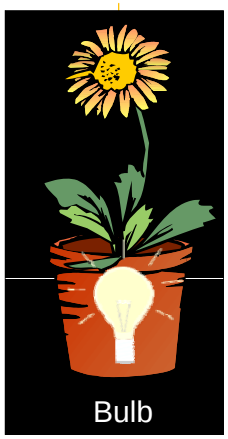
Electric Sources



Light Fixture

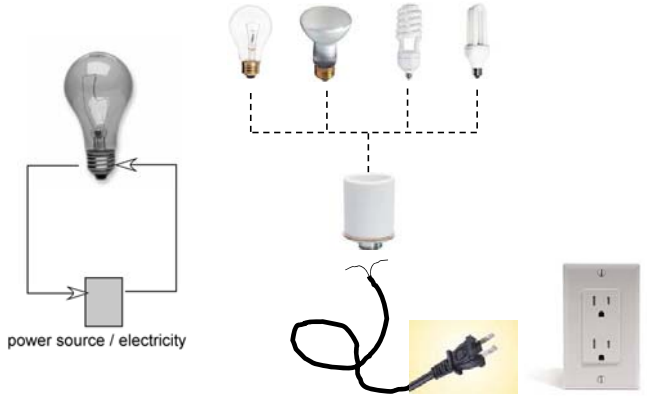
22

Electric Sources



23

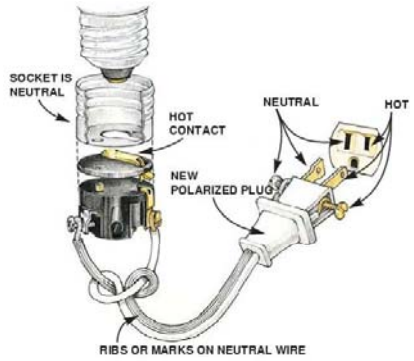
Wiring Basics



24

Making Light: Electric Sources

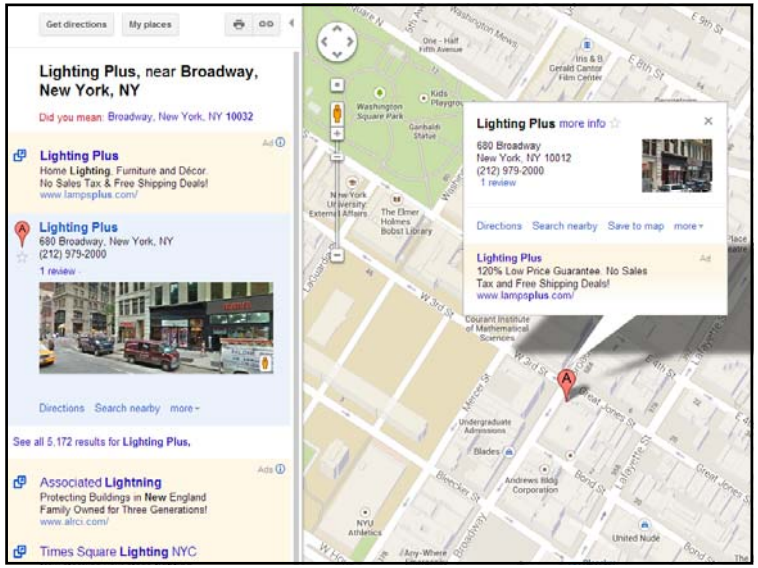
Basic Wiring

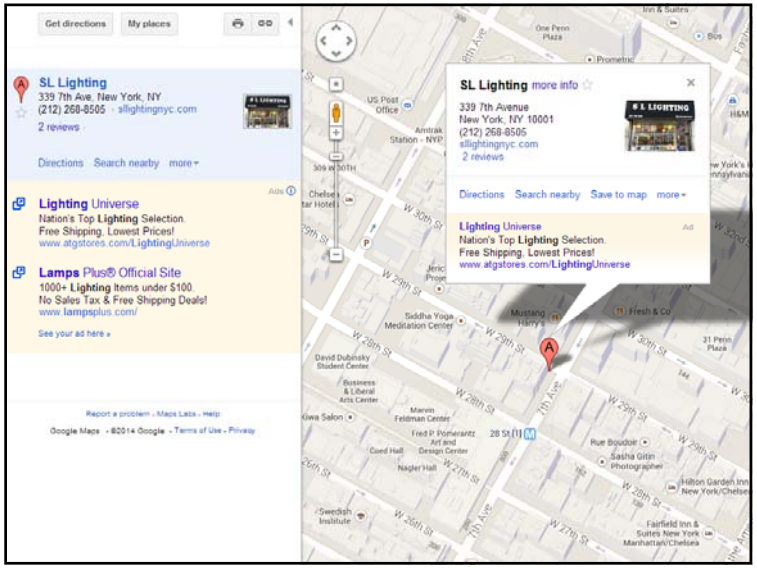


25

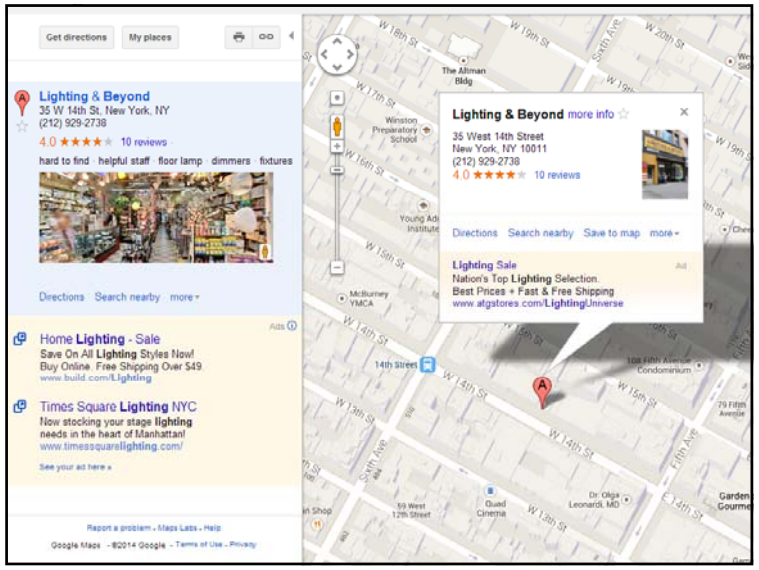
Basic Wiring

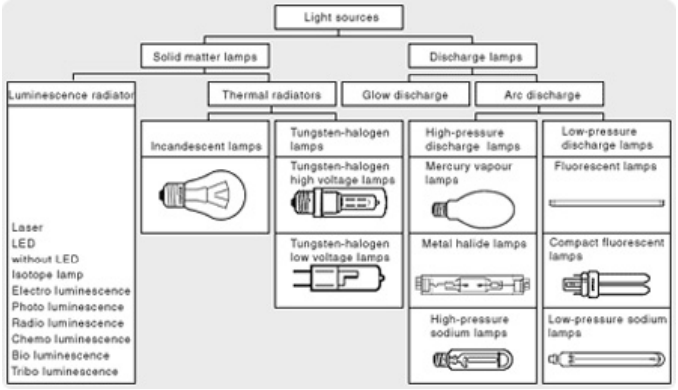
26

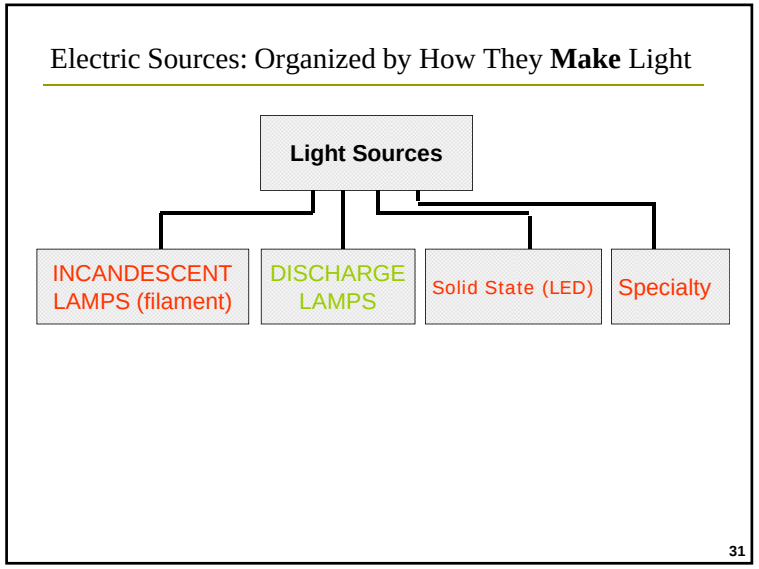


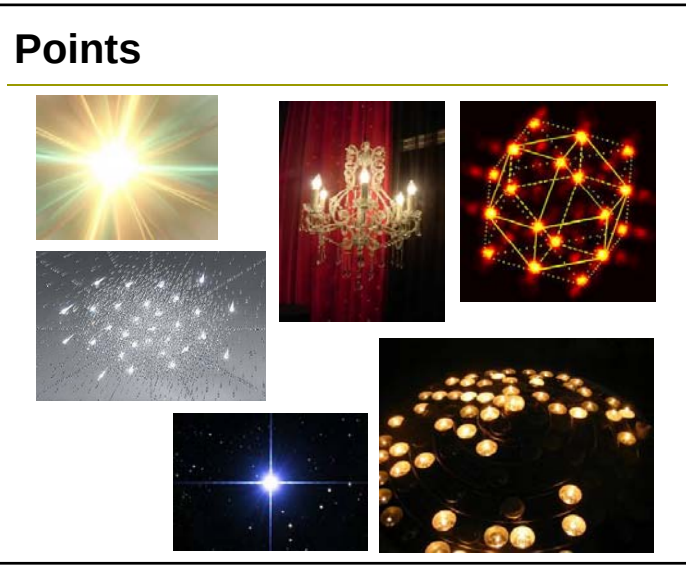


Making Light: Electric Sources









Making Light: Electric Sources

Blobs



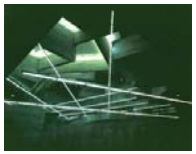



33

Lines







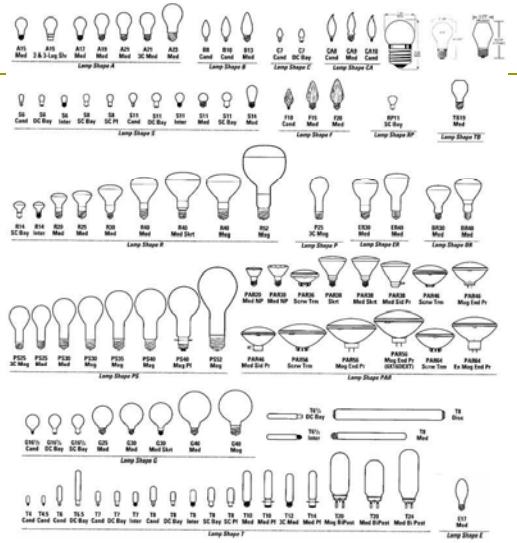
34

Lamp Shape Nomenclature

BULB	NAME	WATTAGE RANGE	TYPICAL APPLICATION
A, P	Cone	4-/W	Nightlights
S, S-11	Straight	3-40W	Sign, Decorative, High Intensity, Appliance
B-10	Decor (Bent or Torpedo)	10-60W	Chandelier and Decorative light fixtures
F	Flame	15-60W	Decorative light fixtures
T	Tubular	6-60W	Aquariums, Appliances, Showcases
G	Globe	10-150W	Kitchen, Bath, Decorative Lighting

BULB	NAME	WATTAGE RANGE	TYPICAL APPLICATION
PAR	Par Straightneck	50-1500W	Most commonly used as Utility or Three-Way
A	Arbitrary	15-250W	General-purpose lighting
R	Reflector	30-1000W	Indoor Directional or Down Lighting
ER	Ellipsoidal Reflector	50-500W	Indoor or Directional Down Lighting
MR	Parabolic Aluminized Reflector	20-500W	Indoor/Outdoor Directional Lighting
BR	Directional Reflector	40-100W	Indoor Directional or Down Lighting
PS	Bulbous Reflector	75-150	Indoor Directional or Down Lighting
G	Globe Tubular	75	Outdoor Pool Lamp Fixtures

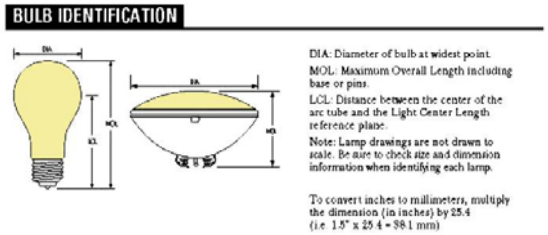
35



36

Making Light: Electric Sources

Lamp Shapes



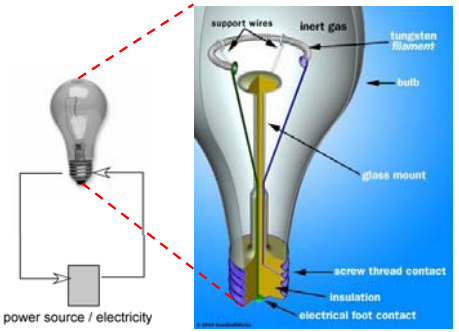
37

Electric Sources: Organized by How They **Make** Light

INCANDESCENT LAMPS (filament)

Incandescent

Halogen



38

How Halogen Lamps Work

39

Points: Halogen Lamps

40

Making Light: Electric Sources

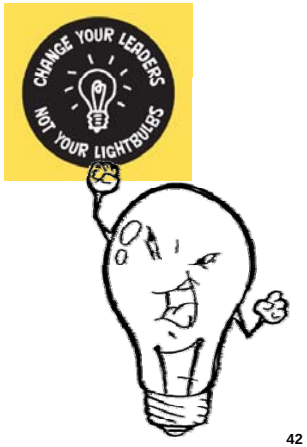
"Blob" Source Halogen Lamps

41

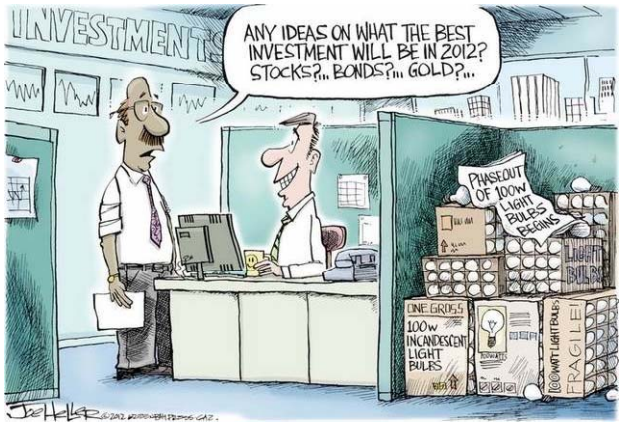
Federal Law is a Performance Standard

"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.



42



43

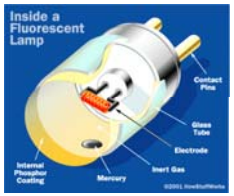
Electric Sources: Organized by How They **Make** Light

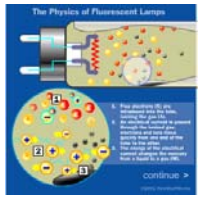
DISCHARGE LAMPS

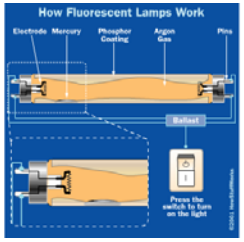
Fluorescent

Linear

Compact





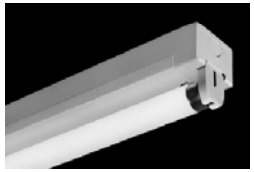


44

Making Light: Electric Sources

Fluorescent Lamp





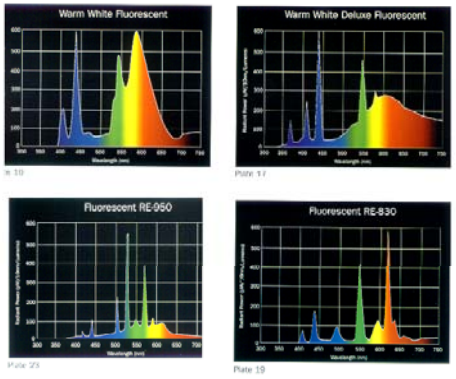

45

Fluorescent Lamp

46

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.

47

How Fluorescent Lamps Work

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

48

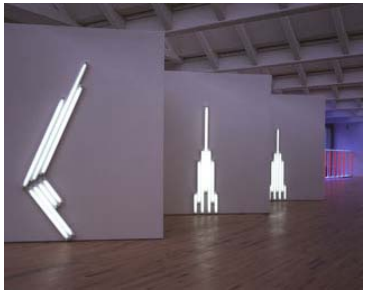
Making Light: Electric Sources

LIGHT is - *To The Artist*



Light

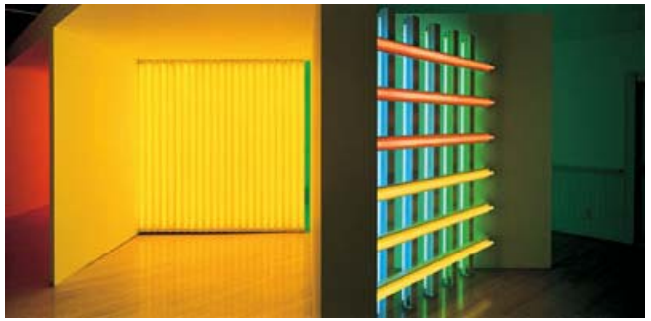
LIGHT is - *To The Artist*

LIGHT is - *To The Artist*



LIGHT is - *To The Artist*

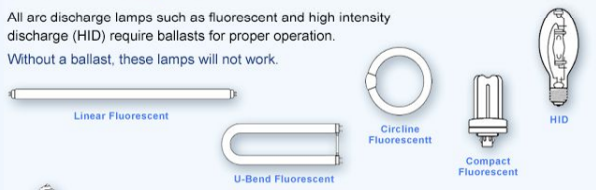


Making Light: Electric Sources

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.



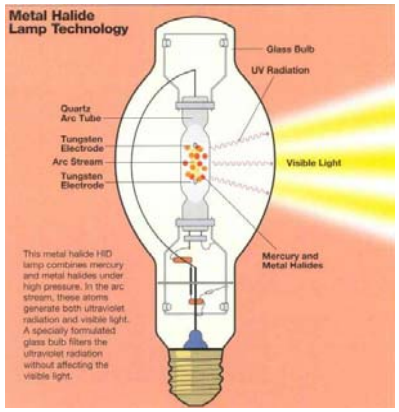
Screw-in compact fluorescent lamps include an extremely small ballast built into the plastic base where the socket is located.

53

Electric Sources: Organized by How They **Make** Light

DISCHARGE LAMPS

High Intensity (HID)



54

Electric Sources - Lamps

Solid State (LED)

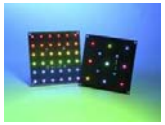
White

Discrete (monochromatic, variable Kelvin)

Retrofit

Color

RGB



Tri-node

55

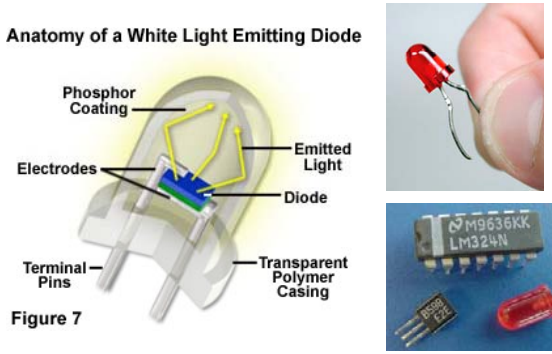
Points: LED's

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

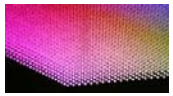
56

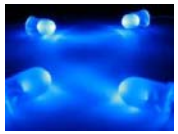
Making Light: Electric Sources

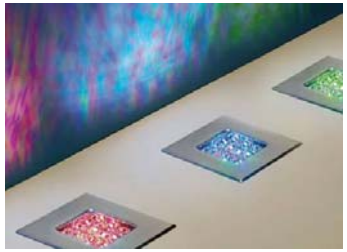
How LED's Work



57

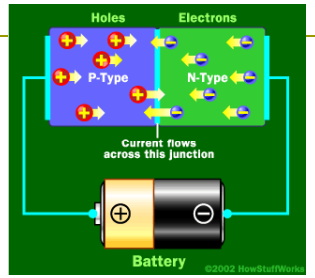


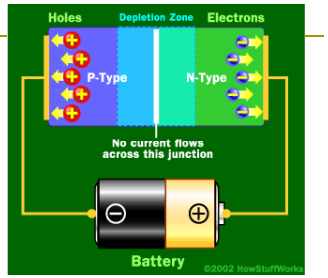




58

59





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.

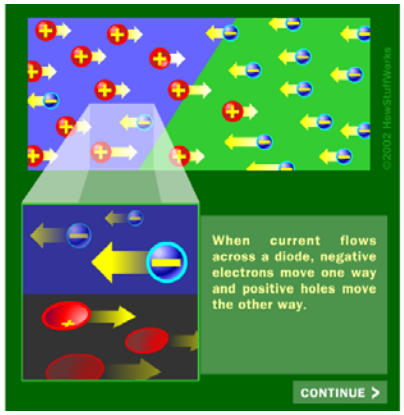
When the positive end of the circuit is hooked up to the N-type layer and the negative end is hooked up to the P-type layer, free electrons collect on one end of the diode and holes collect on the other. The depletion zone gets bigger.

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

60

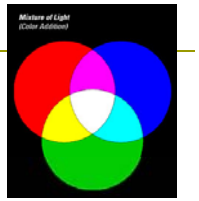
Making Light: Electric Sources

ve.wmv



61

LED



RGB Lighting Systems

Specifier-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.

62

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 enabl 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

iW Blast 12 Powercore | iW Cove Powercore | iW Cast 14 Powercore | iW Profile g2

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

iW Blast 12 | iW MR | iW Profile

63

LED

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

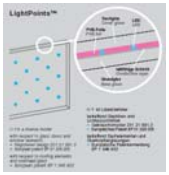
http://www.colorkinetics.com/showcase/videos/wlf_04.htm

64

Making Light: Electric Sources

LED






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

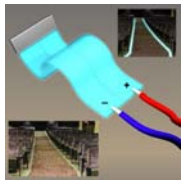
65

Electric Sources - Lamps

Specialty

Neon

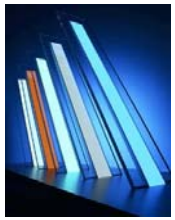
Electroluminescent



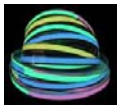
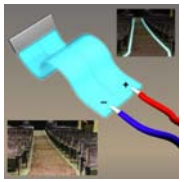

66

Electroluminescent

- http://www.ceelite.com/products/lamps.asp

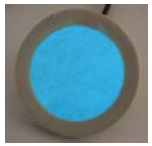





67





68

Making Light: Electric Sources

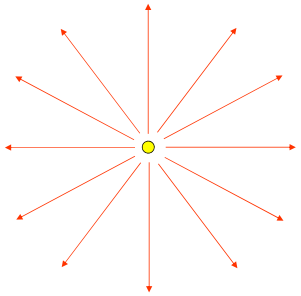
Optical Properties of Light

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

69

Light Direction

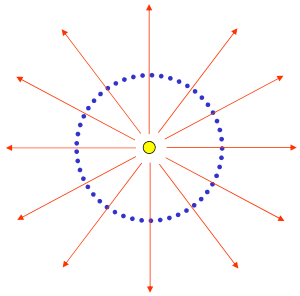
Light travels in a straight line…radiates out from the source



70

Light Direction of Clear Lamps

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

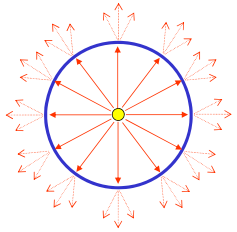


…. add a clear enclosure or envelope around the source, the light will still travel in a straight line.

71

Light Direction of Frosted Lamps

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

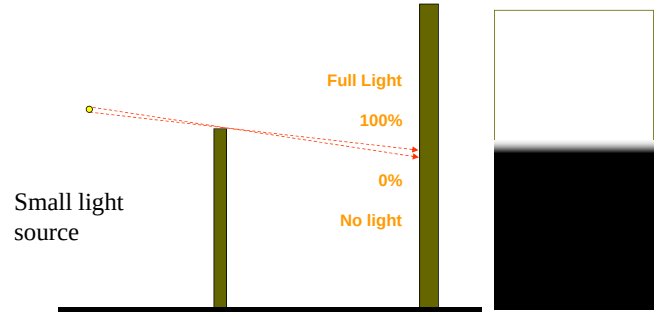


…. add a coated or frosted enclosure or envelope around the source, the direction of light will bend and radiate from the surface of the enclosure

72

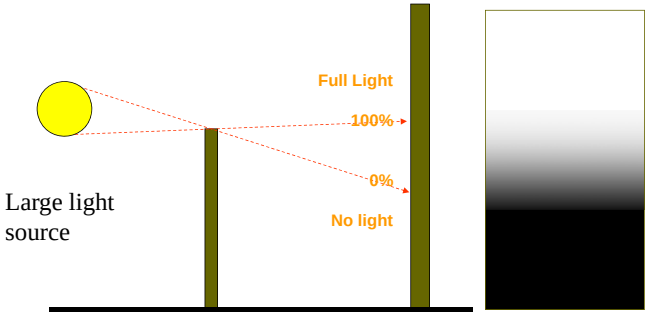
Making Light: Electric Sources

A Shadows Penumbra



73

A Shadows Penumbra



74

Shadow Terminology

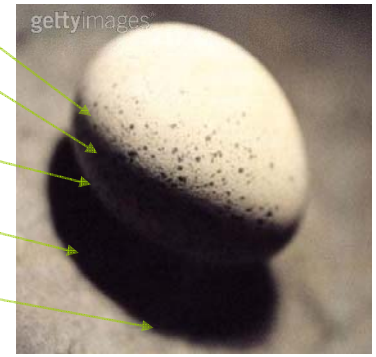
Shading

Attached Shadow

Inter-reflection

Cast Shadow

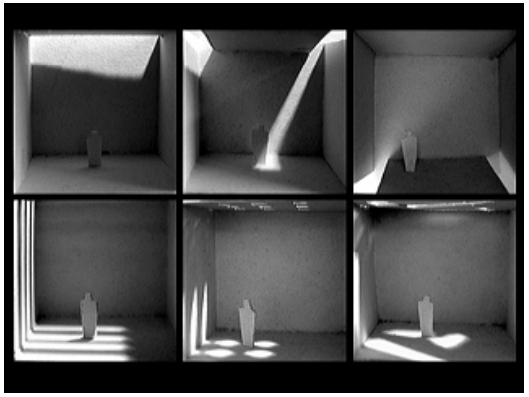
Penumbra



76

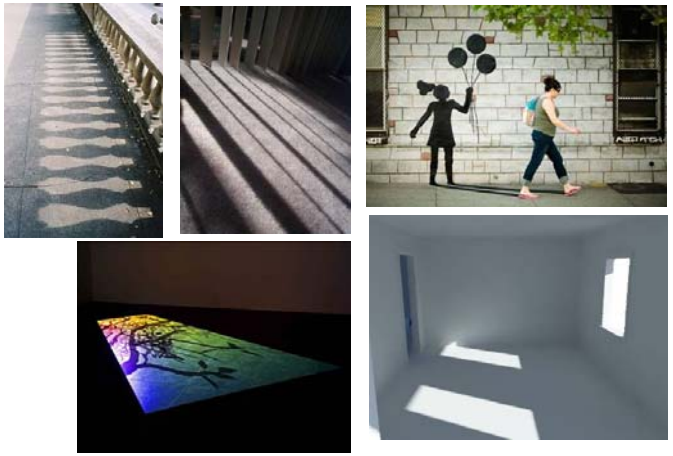
Making Light: Electric Sources

77



78

Projected Patterns of Light



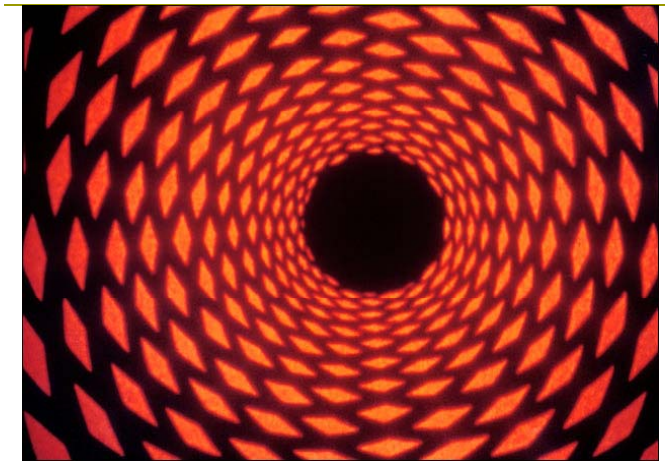
79

Projected Patterns of Light

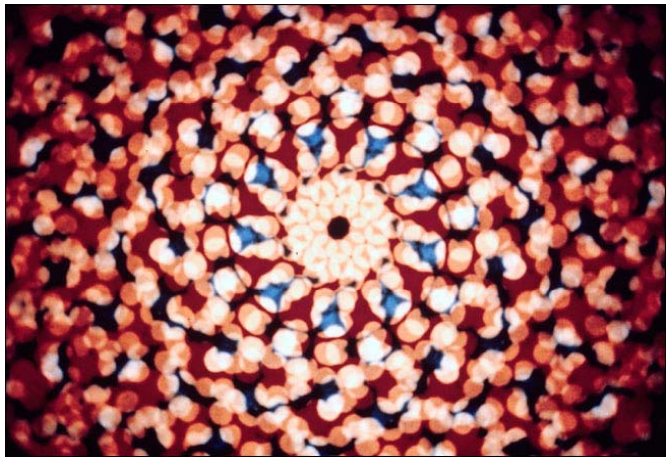
80

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

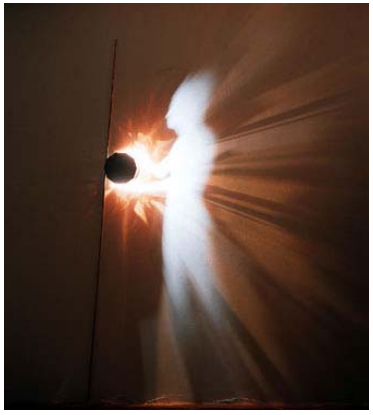




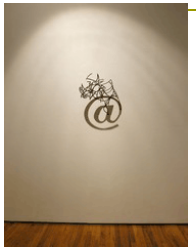

85

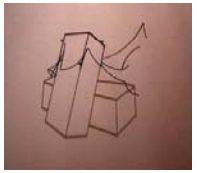
Fabrizio Corneli





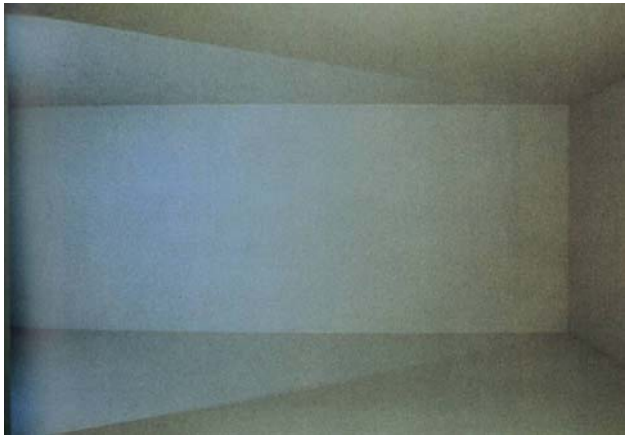
86




Larry Kagan

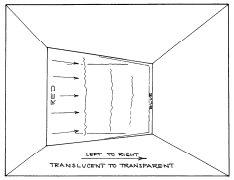
James Turrell "Wedgework"



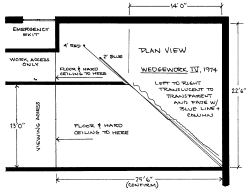
88

Making Light: Electric Sources

James Turrell "Wedgework"

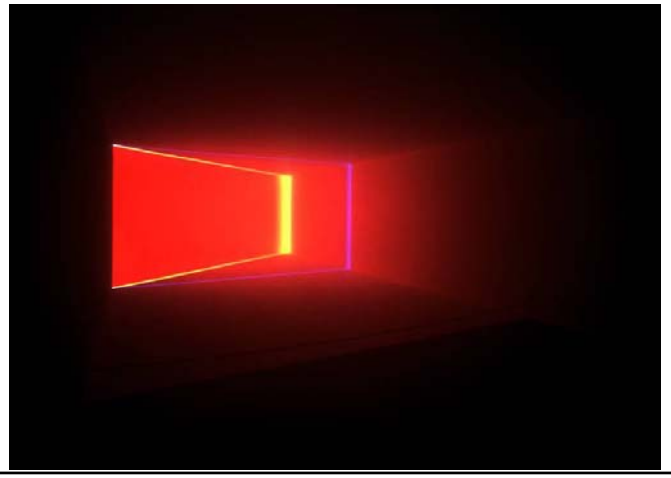


WEDGEWORK IV, 1974 FOR THE HAMMARD
RED FROM LEFT, MINGLING WITH BLUE, BLUE LINE IN CORNER. SCREEN DISSOLVE LEFT TO RIGHT, GOES TO TRANSPARENT.



89

James Turrell



90

Famous Shadows

Famous Shadows

Making Light: Electric Sources

Famous Shadows

Famous Shadows

Grazing Effect

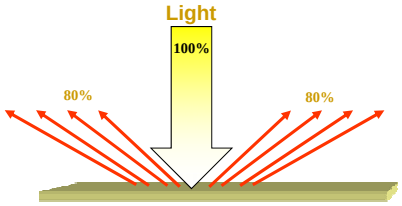
95

Reflected Light

- Optics
  - Absorption
  - Reflection

The material absorbs 20%
- reflects 80%

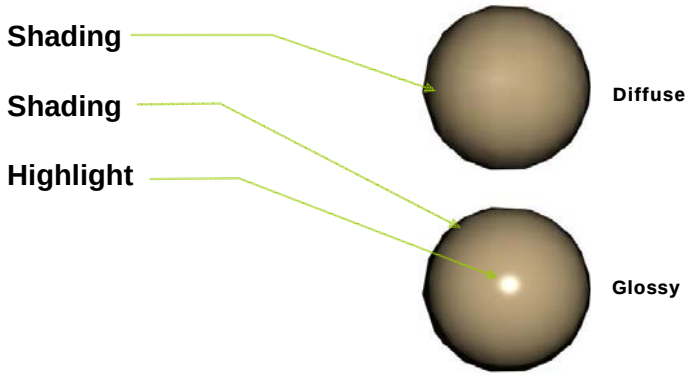
Typical Materials:
Metal
Mirror
Wood



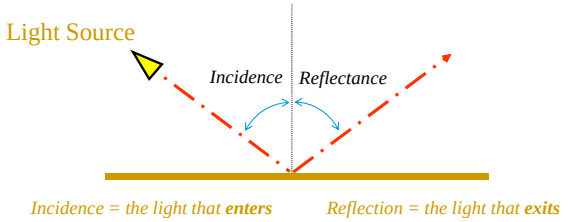
96

Making Light: Electric Sources

Shadow Terminology



Reflection



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

98

Reflected Light

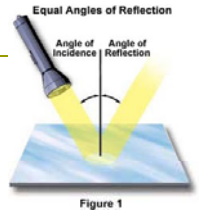
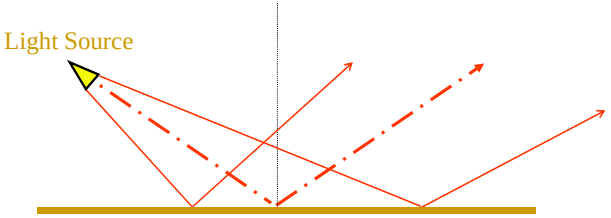


Figure 1

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



99

Reflected Light

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

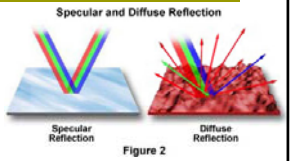
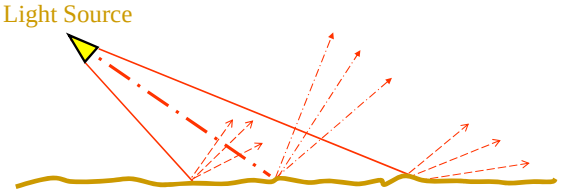


Figure 2

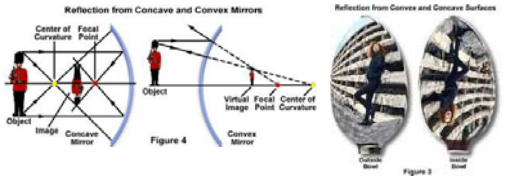


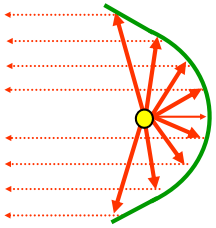
100

Making Light: Electric Sources

Reflector Contours

Parabolic





Reflection Rays are Parallel

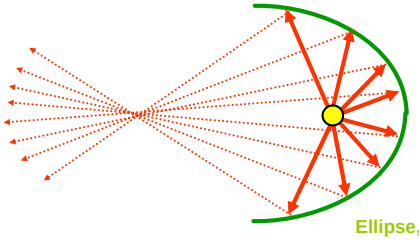
Parabola or Parabolic Reflector

Typically Specular Finish

101

Reflector Contours

Ellipsoidal



Rays converge

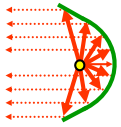
2 foci

Ellipse, Ellipsoidal, or Elliptical Reflector

Typically Specular Finish

102

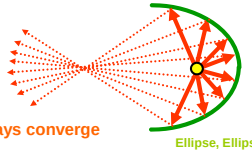
Reflector Contours



Reflection Rays are Parallel

Parabola or Parabolic Reflector

Typically Specular Finish



Rays converge

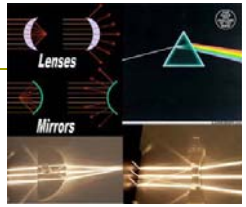
2 foci

Ellipse, Ellipsoidal, or Elliptical Reflector

Typically Specular Finish

103

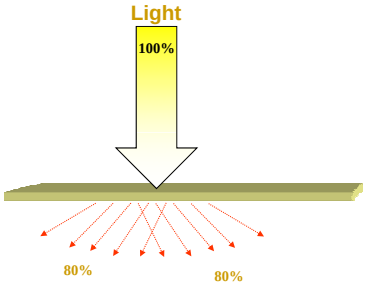
Refracted Light



- Optics
  - Absorption
  - Transmission

The material absorbs 20% - transmits 80%

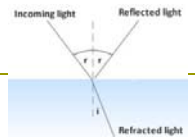
Typical Materials:
Glass
Plastic
Fabric

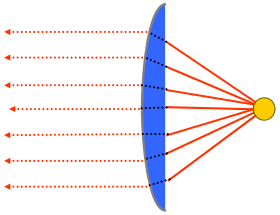


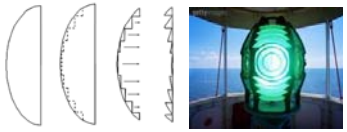
104

Making Light: Electric Sources

Optical Lenses





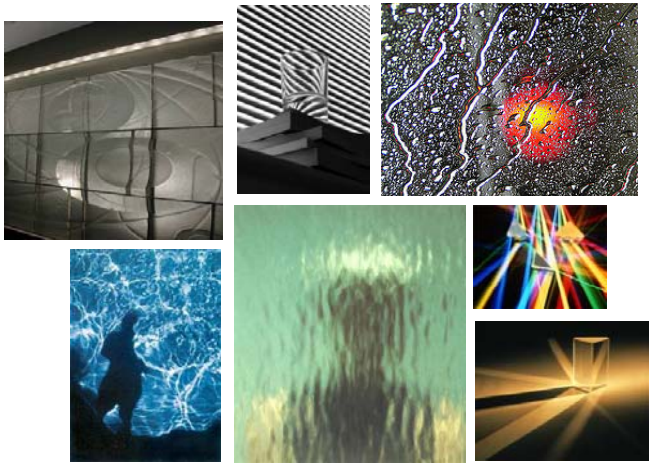


Plano-Convex: diverging rays are refracted to make a parallel beam

Fresnel: Flattened Plano-Conex lens

105

Refracted Light



106

Shadow Terminology

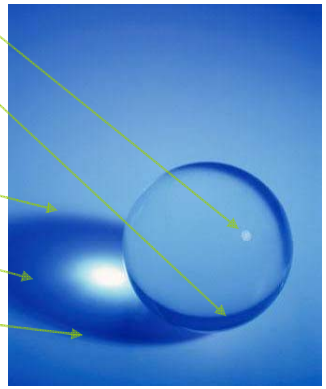
Highlight

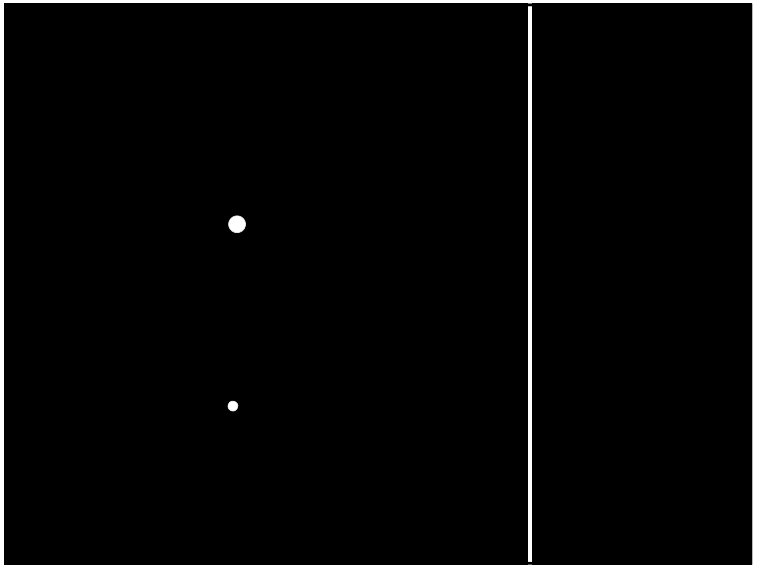
Refracted Shadow

Refracted Light

Cast Shadow

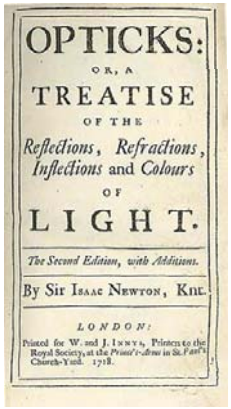
Penumbra

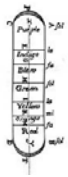


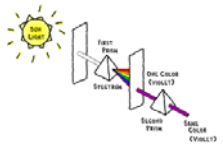


Making Light: Electric Sources

Controlling Light







109

What is Light?

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

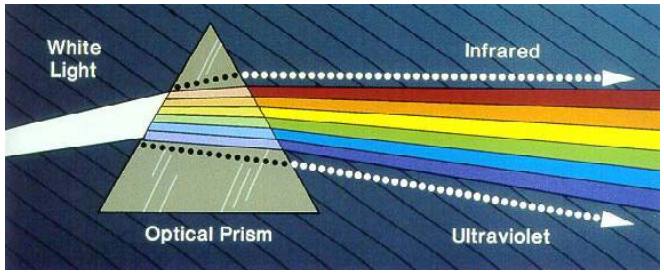
The Light Spectrum	
	Light waves of a specific energy level will emit a particular color.
	Sir Isaac Newton recognized the visible light spectrum in 1666, and he identified seven colors: red, orange, yellow, green, blue, indigo, and violet.
	Newton's colors are arbitrary segments of the continuous spectrum of color.
	When all of the spectral colors travel together, they combine to make white light.

110

Light = Color

111

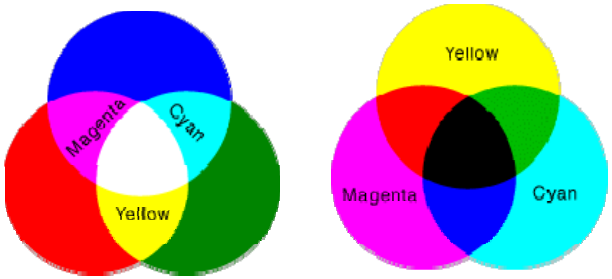
Light = Color



112

Making Light: Electric Sources

Light = Color

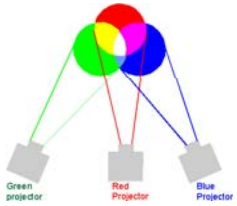


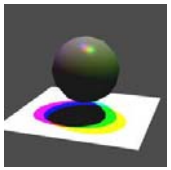
Colors by Addition
Mixture of Light

Colors by Subtraction
Mixture of Pigments

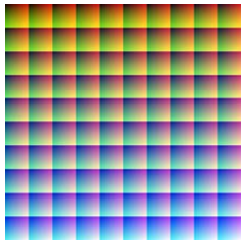
113

Color Mixing



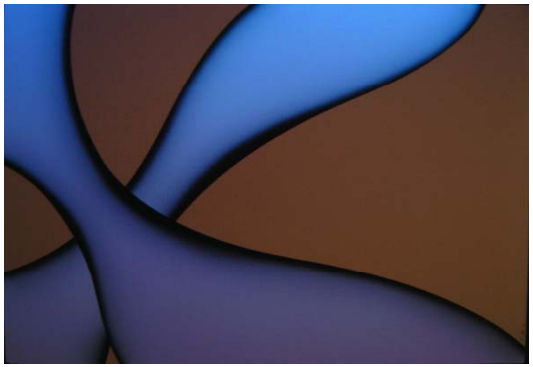


114



115

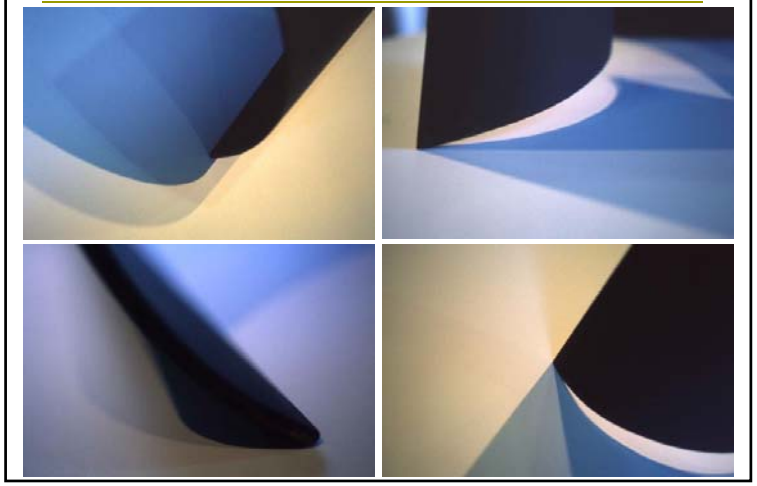
LIGHT is - *To The Artist*

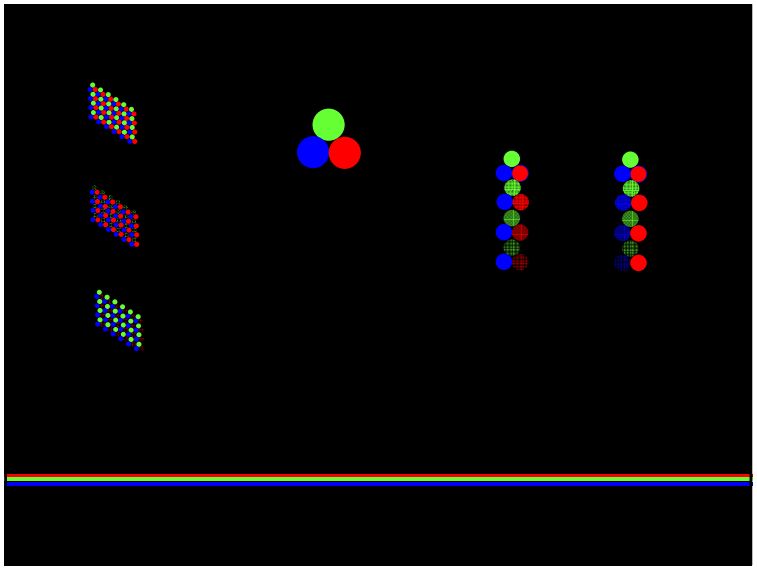


Rufus Knightwebb

Making Light: Electric Sources

LIGHT is – *To The Photographer*

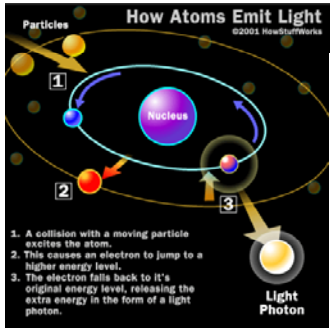




What is Light?

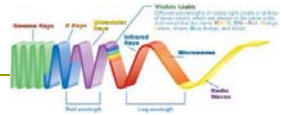
There are two different ways of talking about light:

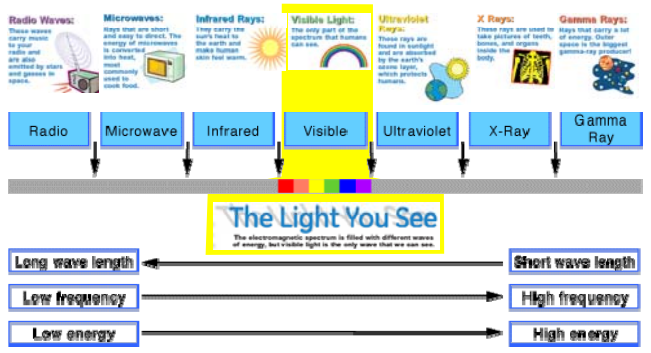
- There is the "particle" theory, expressed in part by the word **photon**.
- There is the "wave" theory, expressed by the term **light wave**.



119

Light = Energy Waves





120

Making Light: Electric Sources

Light = Color

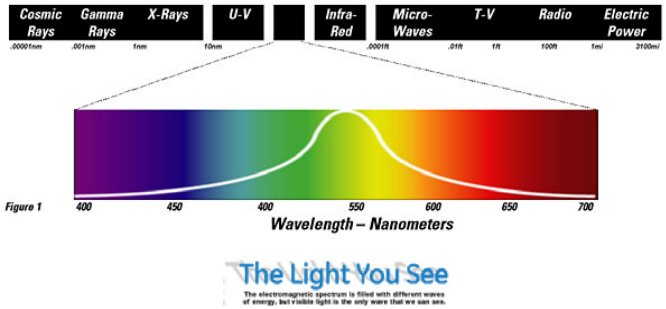
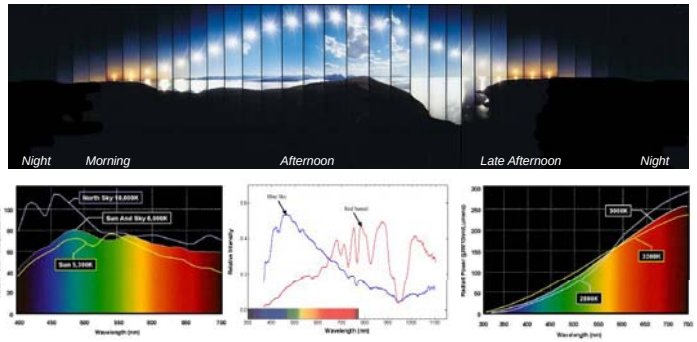


Figure 1

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).

121

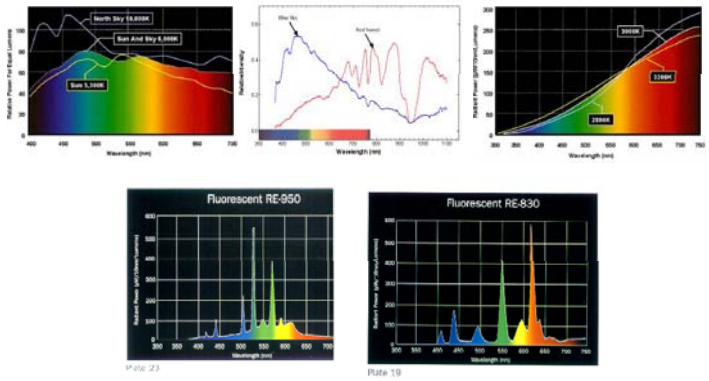
Color Spectrum



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.

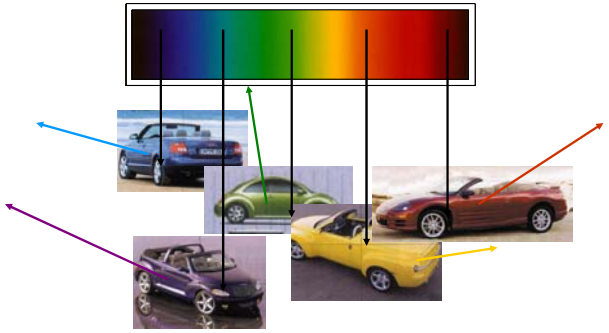
123

Color Rendering Index

how a light source renders the color of objects

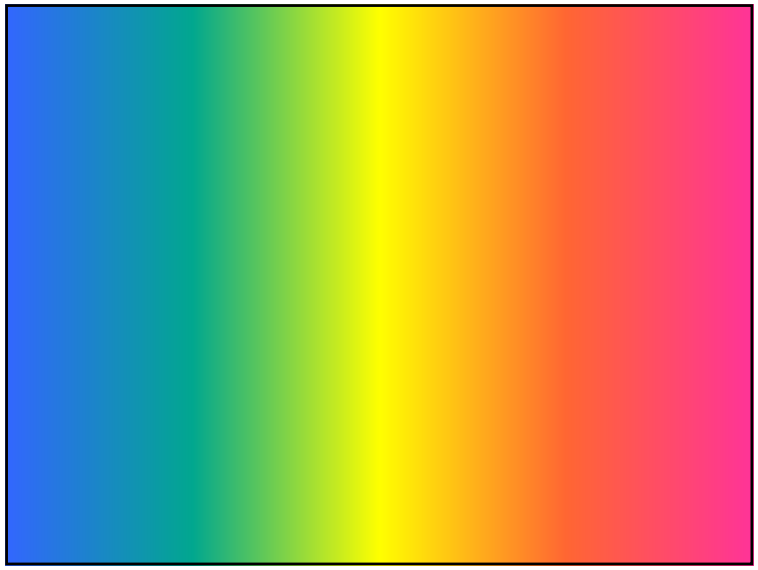
High CRI light makes virtually all colors look natural and vibrant.

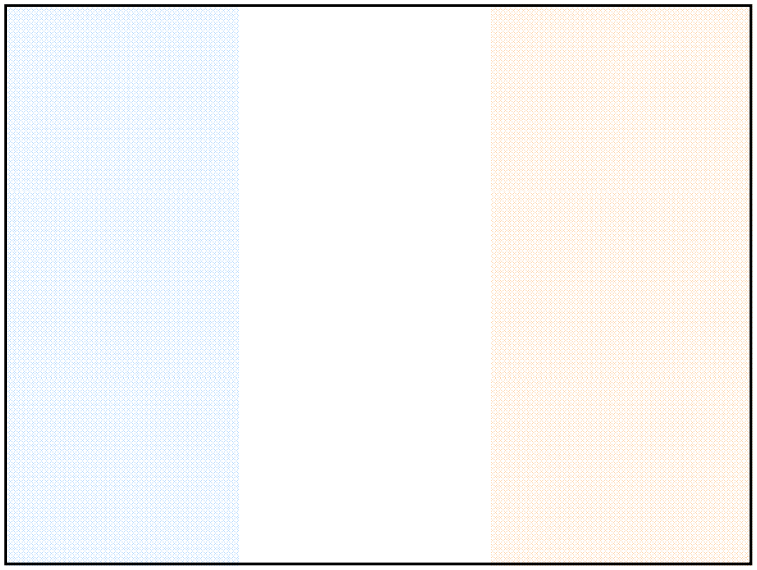
Low CRI causes some colors to appear washed out or even take on a completely different hue.



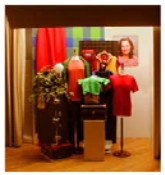
124

Making Light: Electric Sources





Seeing Color


Incandescent / Halogen


CE Cool White


Ceramic Metal Halide


SP30


SP35


HPS

http://www.gelighting.com/na/business_lighting/education_resources/learn_about_light/color_lamp.htm

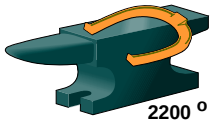
127

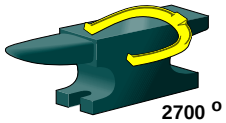
Correlated Color Temperature

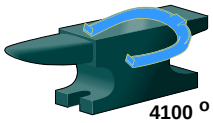
color appearance of various light sources

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

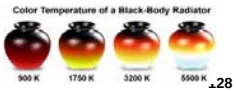
The lower the color temperature (CCT) the "warmer" the color the lamp is in appearance.


2200 °


2700 °


4100 °

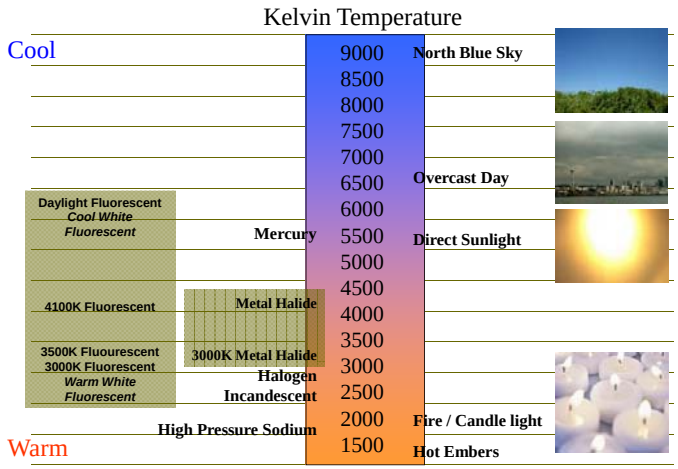
This color temperature is measured in Kelvin.



128

Making Light: Electric Sources

Correlated Color Temperature



129

Correlated Color Temperature

color appearance of various light sources

How does Color Temperature affect the appearance of a room?

5000 deg Kelvin *4000 deg Kelvin* *3000 deg Kelvin*

130

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.

131

"Change a bulb and save the world!"

132

Making Light: Electric Sources

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

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

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

133

The Green Police

Audi 2010 Green Car Super Bowl Commercial

http://www.youtube.com/watch?v=Wq58zS4_jvM

134

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

135

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 beat fluorescents in many categories.
- Do not have negative disposal impacts, fully recyclable
- More efficient to produce, i.e., less embodied energy

136

Making Light: Electric Sources

What is inside the lamp

1. glass
2. steel
3. a small amount of high temperature plastic insulation
4. (lead free?) solder
5. plating material for exposed metal, probably nickel

6. phosphors **
7. mercury + mercury vapor **
8. silicon (in ICs, transistors, MOSFETs, diodes, etc.)
9. fiberglass and epoxy resins (PCB, semiconductor cases)
10. aluminum (electrolytic capacitor)
11. various plastics (main housing, film capacitors)
12. ferrites / ceramics (resistor bodies, choke cores)
13. copper wire and PCB traces

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

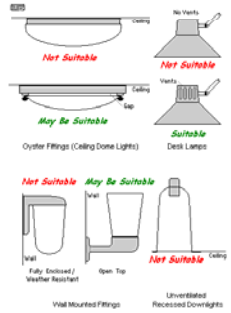
1. glass
2. steel
3. a small amount of high temperature plastic insulation
4. (lead free?) solder
5. plating material for exposed metal, probably nickel

6. tungsten
7. inert (and naturally occurring) gas

137

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.)



138

$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.

139

CHANGE FOR THE BETTER WITH ENERGY STAR

Products that earn the ENERGY STAR prevent greenhouse gas emissions by meeting strict energy efficiency guidelines set by the U.S. Environmental Protection Agency and the U.S. Department of Energy. www.energystar.gov

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

<u>How should I clean up a broken fluorescent bulb?</u>
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.

140

Making Light: Electric Sources

How Florescent Lamps are Recycled

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 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 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 4

- The remaining components are then further separated generating three process streams, glass cullet, glass fines, and phosphor powder.
- Of total bulb weight, roughly 98% 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 retorted to reclaim mercury.

SYLVANIA

141

Lamp Manufactures

General Electric
www.gelighting.com

Philips
www.lighting.philips.com

Osram / Sylvania
www.sylvania.com

Others

Venture Lighting
http://www.venturelighting.com/

Ushio America Inc
http://www.ushio.com/

142