

# De Anza ES 74 Lighting Systems - Lecture #1

Scott Gould  
Instructor

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## Course Objectives

- Explore how light is produced and delivered by examining various lighting technologies and the efficiency associated with each technology
- Explore the relationship between lighting, vision, and human perception
- Examine the benefits and applications of compact fluorescent lighting
- Examine the benefits and applications of fluorescent lighting

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## Course Objectives cont.

- Assess the essential role of ballasts in a lighting
- Explore the various types of lighting controls and the benefits of their use
- Examine principles, applications and technologies for exterior lighting
- Explore the theory and benefits of daylighting as an alternative to electric lighting
- Explore the life cycle benefit of different lighting options in retrofit and new construction applications.

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## Logistics

- <http://bhs.deanza.edu/faculty/sGould/index.htm>
- Field Trip
- Reading assignment -- See NLPiR web page  
<http://www.lrc.rpi.edu/nlpip/listoftechnologies.cfm>
- Scott Gould email is [scott.gould@stanford.edu](mailto:scott.gould@stanford.edu)

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## Lighting - Magnitude of Use

- Lighting consumes 20 % of the electricity generated in the US.
- Lighting represents approximately 40% of the electrical consumption for a typical office building

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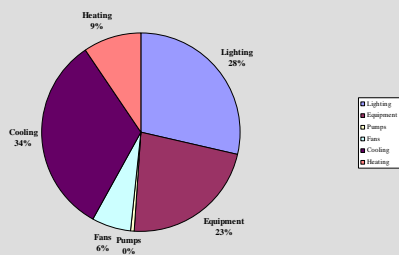
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## Classroom Energy Balance



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## Pollution Prevention

- EPA estimates that for every kWh per year saved the following amounts of pollution are prevented:
  - 1.0 lbs/yr CO<sub>2</sub>
  - 1.1 g/yr SO<sub>2</sub>
  - 1.5 g/yr NO<sub>x</sub>
- For CA. Numbers are aggregated by US region

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## Lighting Efficiency Drivers

- EPA "Green Lights" Program
  - Launched in 1991
  - Maximize energy savings
  - Maintain or improve lighting quality
  - Implement Cost effective upgrades within 5 years
- EPA Labeling Program
- EPC Act - 1995 standards for fl lamps
- Utility Rebate Programs
- Title 24 in CA

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## Importance of Lighting Quality

- Operating Cost per square foot (sqft)\*
  - 85% Wages and benefits
  - 6% Space
  - 5% Services and Supplies
  - 3% Furniture and Equipment
  - 1% Lighting!

\*From EPA Green Lights Program

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## Subjective Nature of Light

- Restaurant
- Sports Arena
- Classroom
- Assembly Line
- Parking lot

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## Lighting Definitions

- Watt = power input
- Lumen = light output
  - Typically see lumens per watt for a light source
- Footcandle = light level measured in lumen/sqft
  - Lux = SI unit of illuminance
    - One lumen per square meter
    - 10 lux = approximately 1 fc.

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## Lighting Definitions cont.

- Efficiency usually refers to luminaire efficiency
- Efficacy = lumens per watt
- Voltage
  - 120
  - 277

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## Glare

- The effect of differences in brightness within the visual field sufficiently high to cause discomfort or loss of visual performance.
  - Windows
  - Computer screens

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## Color Rendering

- Color Rendering Index (CRI)
  - Compares lighting to reference source
    - 75 to 100 Excellent CRI
    - 55 to 75 Fair to Good CRI
    - Less than 55 Poor CRI
- Incandescent 100 CRI
- Fluorescent low 50s to 90+ CRI

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## Color Temperature

- Color Temperature
  - Measured in degrees "k"
  - "Warm" or red spectrum <3000 k
    - Restaurant or low light level
  - "Cool" or blue spectrum >4000 k
    - Hospital or high light level
- Example Color Temperature
  - Overcast sky 7000 CRI
  - Summer Sky 5500 CRI
  - Incandescent 2500 CRI
  - Candle 2000 CRI Very Warm Light!

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## Recommended Lighting Levels

- IES -Illuminating Engineering Society
  - Age
  - Task - Demand for accuracy
    - Not important
    - Important
    - Critical
  - Average Room Reflectance

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## Recommended Lighting Levels

- Lighting level example:
  - Hallway 5 to 10 fc
  - Computer use 20 to 30 fc
  - Typical office 20 to 50 fc
  - Low contrast and small size tasks 100 to 150 fc
  - Prolonged and exacting tasks 500 to 1000 fc
- Uniformity is key
  - Spacing
  - Mounting height

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## Avoid Excessive Illumination

- Visual Discomfort
  - Eye strain
  - Headaches
  - Fatigue
- Energy and Dollars Wasted
- Associated Pollution

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## Incandescent

- General Service
- Reflector Types
- PAR Parabolic Aluminized Reflectors
- Industrial grade (130v) long life

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## Incandescent / Halogen

Wattage 3 to 1500  
System Efficacy 6- 24 (18-33)  
Average rated life 750 to 2000 hours (4000)  
CRI 95+  
Life Cycle Cost high  
Fixture size compact  
Start to full brightness immediate  
Restrike time immediate  
Lumen Maintenance good/excellent

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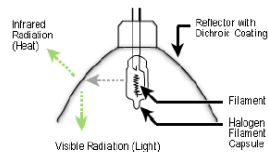
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## MR16 Halogen

Figure 2-2. Schematic diagram of how a dichroic coating works



MR 16 = 16 eights = 2 inches in Dia

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## Fluorescent

Wattage 4 to 215  
System Efficacy 50 to 100  
Average rated life 7,500 to 24,000 hours  
CRI 49 to 92  
Life Cycle Cost low  
Fixture size extended  
Start to full brightness 0-5 sec  
Restrike time immediate  
Lumen Maintenance good

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## Compact Fluorescent

Wattage 5 to 40  
System Efficacy 50 to 80  
Average rated life 10,000 to 20,000  
CRI 82 to 86  
Life Cycle Cost moderate  
Fixture size compact  
Start to full brightness 0-1 minute  
Restrike time immediate  
Lumen Maintenance good

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## HID - Mercury Vapor

Wattage 40 to 1,250  
System Efficacy 25 to 50  
Average rated life 24,000  
CRI 22 to 52  
Life Cycle Cost moderate  
Fixture size compact  
Start to full brightness 2 to 5 minute  
Restrike time 3 to 10 minute  
Lumen Maintenance poor fair

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## HID --Metal Halide

Wattage 32 to 2000  
System Efficacy 50 - 115  
Average rated life 6,000 to 20,000  
CRI 65 to 92  
Life Cycle Cost moderate  
Fixture size compact  
Start to full brightness 2 to 5 minutes  
Restrike time 10 to 20 minutes  
Lumen Maintenance good

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## HID - High Pressure Sodium

Wattage 35 to 1000  
System Efficacy 40 -140  
Average rated life 16,000 - 24,000  
CRI 21 to 80  
Life Cycle Cost low  
Fixture size compact  
Start to full brightness 4 to 6 minutes  
Restrike time 1 minute  
Lumen Maintenance good/excellent

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## Low Pressure Sodium

Wattage 18 to 180  
System Efficacy 120 -180  
Average rated life 12,000 to 18,000  
CRI 0 to 18  
Life Cycle Cost low  
Fixture size extended  
Start to full brightness 10 to 15 minutes  
Restrike time immediate  
Lumen Maintenance excellent

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## Compact Fluorescent Lamps

- Energy Efficient Substitute for incandescent lamps
  - Modular
  - Integral
  - Dedicated
- Good color rendering
- Flexible
- Limitations
  - Light can be "trapped" in a recessed can fixture
  - Retrofits are not usually dimmable
  - Output is affected by temperature and orientation

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## Fluorescent Lamps

- Lamps maintain an electric arc through through a mercury vapor and inert gases.
- Base pins, cathode, phosphor coatings, are also parts of the lamp.
- Starting methods include
  - Preheat, rapid start, and instant start (slimline),

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## Fluorescent Lamps (Linear)

- Four foot types
  - T12 40 watt and 34 watt
  - T10
  - HO and VHO
- "U" Shape
- Also available in 2 to 8 foot lengths
- New lamp types

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## Fluorescent Ballast

- Starting Voltage
- Regulates lamp current and power quality
- Types:
  - Magnetic core and coil
  - "efficient" magnetic core and coil
  - Hybrid
  - Electronic

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## Electronic Ballasts

- High-frequency operation increases fluorescent lamps efficacy
- Capable of operating up to 4 lamps
- Dimmable
- Instant Start
- Rapid Start

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## Ballast Factor

- Fraction of rated lamp lumens produced by a specific lamp-ballast combination
  - High Ballast Factor (1.0+) increases light output and energy consumption
  - Typical Ballast Factor (0.85 to 0.95)
  - Low Ballast Factor (.83 or lower) decreases light output and energy consumption

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## Total Harmonic Distortion (THD)

- Higher multiples of the 60hz frequency superimposed on the AC waveform
- Caused by switching power supplies - ballasts, computers, fax machines
- Results in increased neutral current, decreased power factor, increased voltage distortion.

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## THD cont.

- Example THD
  - Magnetic ballast
    - Compact FL 8 to 30 %
    - Full size FL 12 to 30 %
  - Electronic Ballast
    - Compact FL 18 to 180%
    - Full size FL 5 to 30%
- Recommended 32% max THD

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## Electromagnetic Interference (EMI)

- Radio Interference from Lamps and Ballasts that is either radiated or conducted.
- Can cause problems with telephones, remote controls, etc.
- Can be minimized by proper grounding and filtering.

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## Power Factor

- A measure of how effectively an electrical load converts power into useful work.
- PF =  $\text{active power}/(\text{rms V} \times \text{rms A})$ .
- Ballast with low power factor require more current per watt consumed.

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## Light Meter

- In class...
  - Desk Level Readings
  - Measure footcandles
  - Note: Difficult to measure low levels of light (under 5 fc)

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## To Do List

- Homework Assignment
- Sign up for emptlist
- Start Journal
- Read T8 Article
- Download articles from the National Lighting Product Information Program

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## Review Lecture 1

- Definitions
- Lighting Quality
  - Average Light Level
  - Uniformity of Illumination
  - Direct/Reflected Glare
  - Color Rendering
  - Color Temperature
- Lamp Types

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## Sample Resources

EPA Energy Star

[http://www.energystar.gov/index.cfm?c=lighting.pr\\_lighting](http://www.energystar.gov/index.cfm?c=lighting.pr_lighting)

National Lighting Product Information Program

<http://www.lrc.rpi.edu/programs/NLPIP/publications.asp>

LightSearch.com

<http://www.light-link.com/>

GE School Lighting Challenge

<http://www.gelighting.com/na/home/gela/index.htm>

Lightsite

<http://www.lightsite.net/index.html>

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