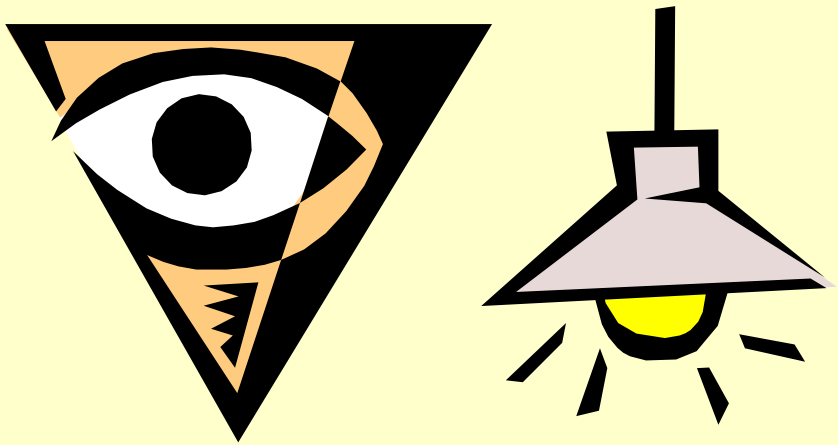
SBS5312 Lighting Technology

http://ibse.hk/SBS5312/



Introduction

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Aug 2017

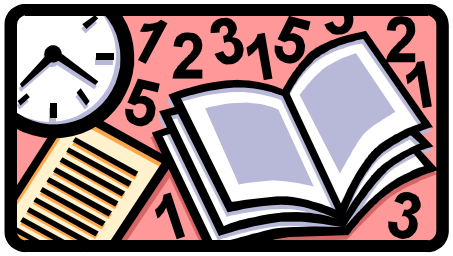
Contents

- Background
- Things You Need to Know
- Purpose of Lighting
- Terminology
- System Overview
- Lighting Analysis Tools

Nowadays, An Exciting Time for Lighting…

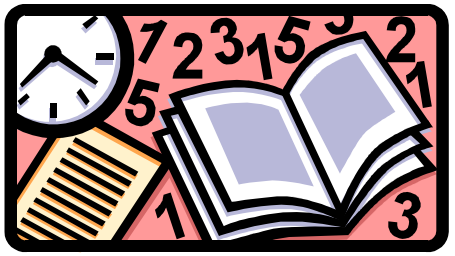
☼ Energy efficient lighting, LED, daylight harvesting, digital controls, wireless controls, smart luminaires, integrated lighting…

Background



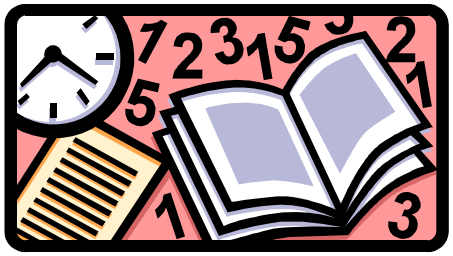
- Module Aims:
  - This module covers a wide range of lighting systems and their applications in illuminating buildings indoors and outdoors.
  - The module aims at enabling students to identify, analyse and evaluate basic components and features in lighting systems; and then to apply these components appropriately in lighting design of buildings.

Background

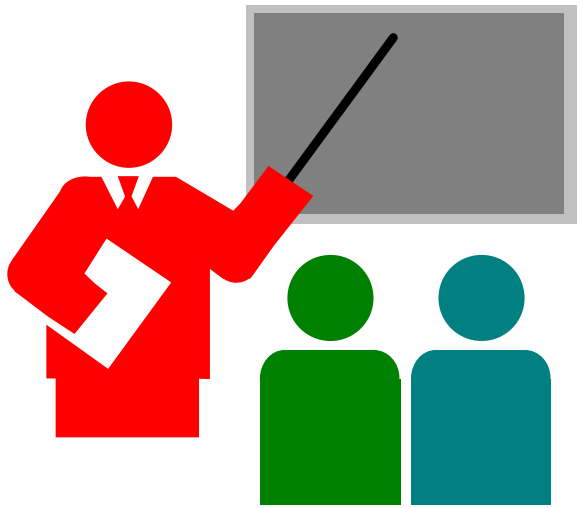


- Learning Outcomes:
  - 1. describe the characteristics of light sources and lighting systems, including daylighting systems;
  - 2. select suitable lighting systems and components for indoors and outdoors;
  - 3. critically assess the energy consumption using photometric and colorimetric calculation for lighting design; and
  - 4. evaluate the impact of human factors, economy and energy on lighting design of buildings.

Background



- Lecturers:
  - Ir Dr Sam C M Hui (cmhui@vtc.edu.hk)
  - Dr Ernest Tsang (ernest_tsang@vtc.edu.hk)
- Assessment Methods:
  - Assignment (20%)
  - Test (10%)
  - Laboratory work (10%)
  - Examination (60%) (3 hours)
- Course Website:
  - http://ibse.hk/SBS5312/



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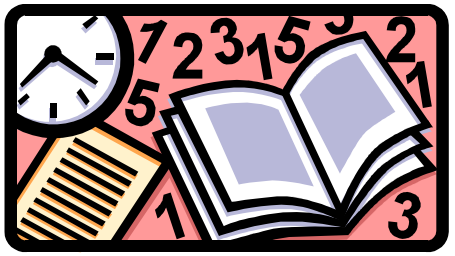
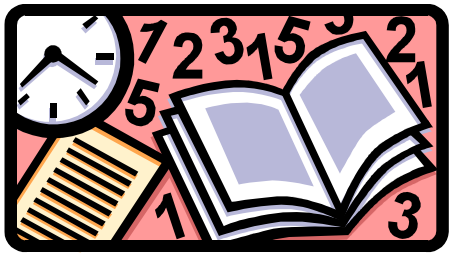


- ***Ir. Dr. Sam C. M. Hui*** (*Building Services Engineer*)
  - PhD, BEng(Hons), CEng, CEM, BEAP, BEMP, HBDP, MASHRAE, MCIBSE, MHKIE, MIESNA, LifeMAEE, AssocAIA
    - CEng = Chartered Engineer
    - CEM = Certified Energy Manager
    - BEAP = Building Energy Assessment Professional
    - BEMP = Building Energy Modeling Professional
    - HBDP = High-performance Building Design Professional
    - LifeMAEE = Life Member, Association of Energy Engineers
  - ASHRAE Distinguished Lecturer (2009-2011)
  - 20 yrs. teaching in HKU Departments of Architecture and Mech. Engg.
  - Research interests: energy efficiency in buildings and sustainable building technologies

Background



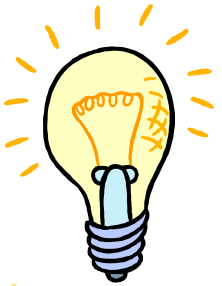
- Study topics:
  - Introduction
  - Lighting: basic concepts
  - Light sources and systems
  - Indoor lighting design
  - Lighting calculations
  - Computer-aided lighting design
  - Lighting energy management

Dr. Hui

  - Daylighting design (I)
  - Daylighting design (II)
  - Visual performance and comfort
  - Light pollution and environmental issues

Dr. Tsang

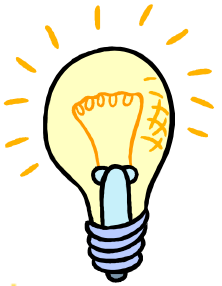
Things You Need to Know



- Who are involved in Lighting Design?*
  - Architects
  - Engineers
    - ***Building Services Engineers***
    - Electrical Engineers
    - Lighting Engineers
  - Interior Designers
  - Lighting Designers (specialist)

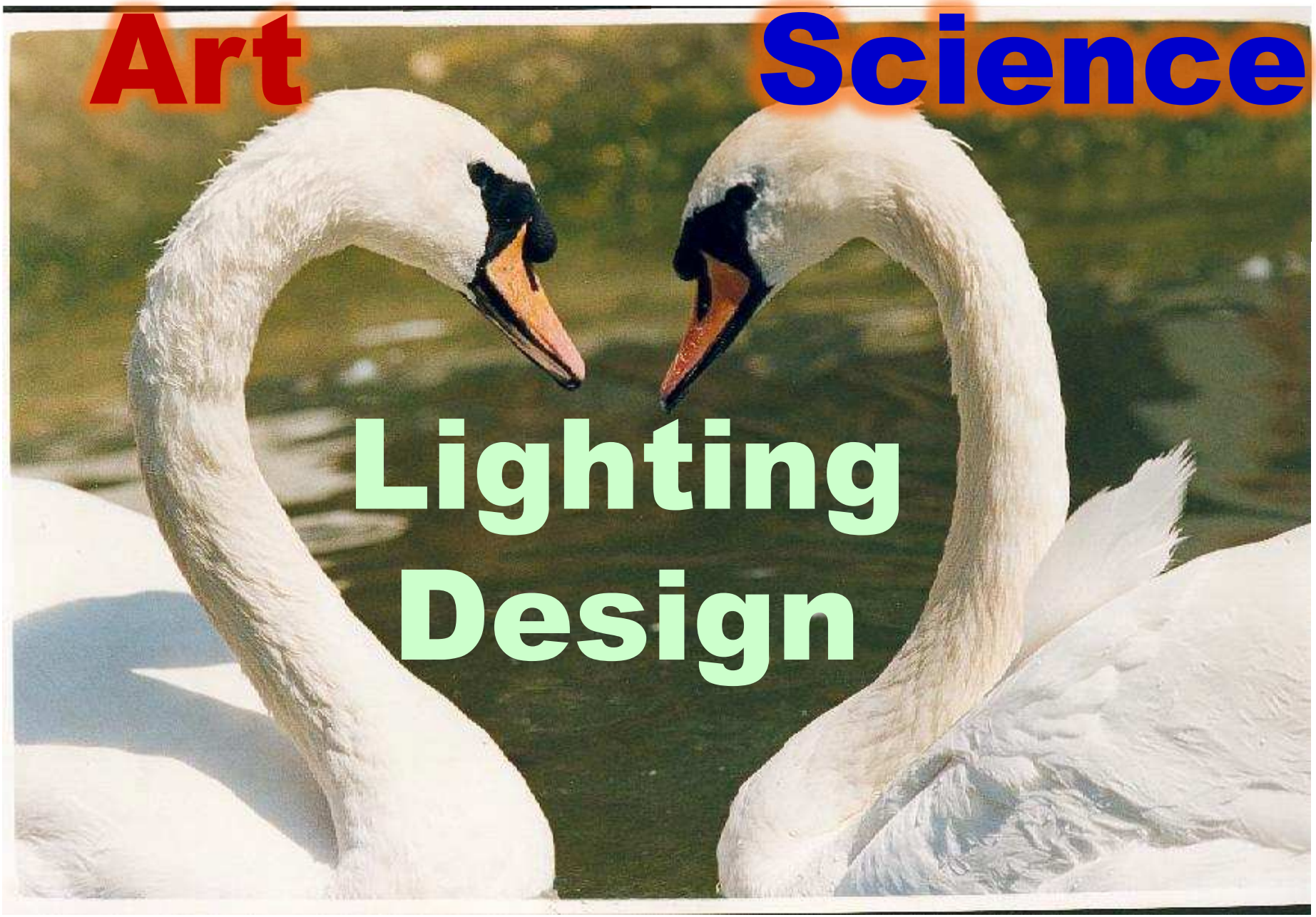
(* See also http://en.wikipedia.org/wiki/Architectural_lighting_design)

Things You Need to Know



- Professional societies on *Lighting Design*
  - Illuminating Engineering Society of North America (IESNA) [now renamed as IES]
    - http://www.ies.org
  - Commission Internationale de l'Eclairage (CIE) (International Commission on Illumination)
    - http://www.cie.co.at
  - Society of Light and Lighting, UK (under CIBSE*)
    - http://www.cibse.org

*CIBSE = Chartered Institution of Building Services Engineers


Art
Science
Lighting
Design

Things You Need to Know

- Lighting design is the science and art of making things useful to humankind; and it is the application of lighting -- including daylight when it is specifically used as a source of lighting -- to human spaces
- Lighting design relies on a combination of specific scientific principles, established standards and conventions, and a number of aesthetic, cultural and human factors applied in an artful manner

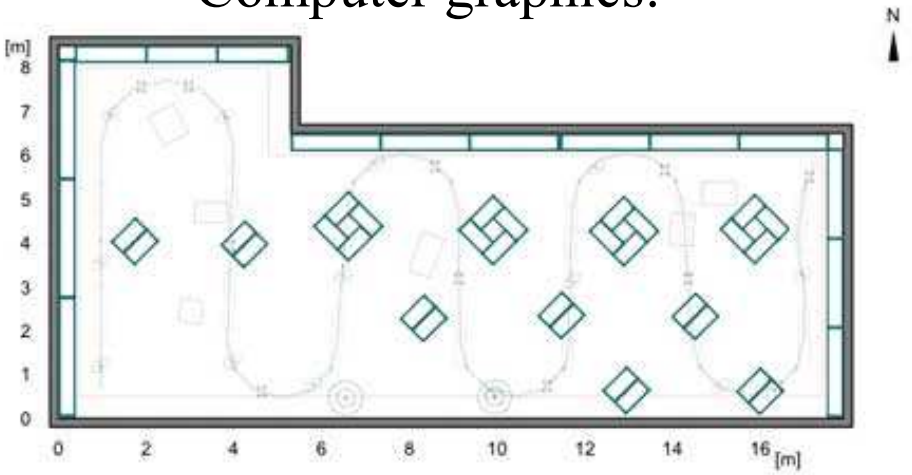
Things You Need to Know

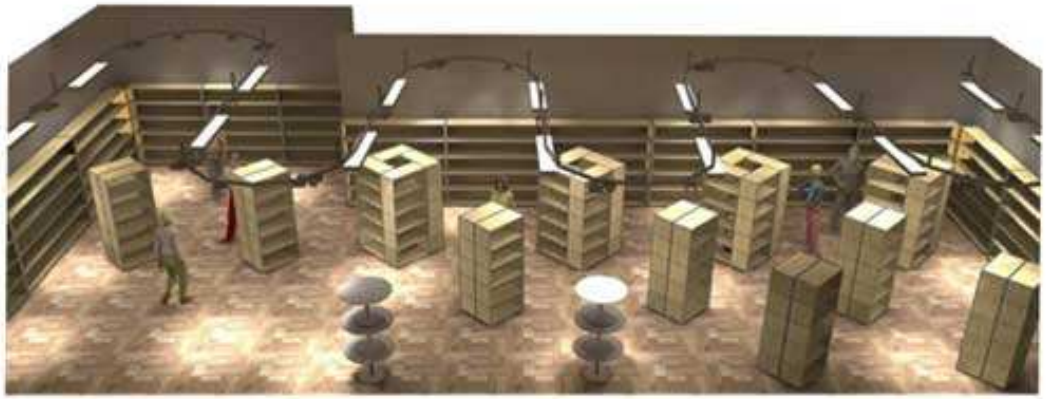
- As a **SCIENCE**
  - The amounts of illumination needed and certain aspects of the quality of light are quantified
- As an **ART**
  - Attaching numbers is meaningless because light is an experience of the SENSES
    - Lighting can motivate people to be active, relaxed, productive, lively or depressed
    - Create an atmosphere pleasing to the occupants
    - Provide visibility, character, and mood as well as relate harmoniously to the space in which it is used

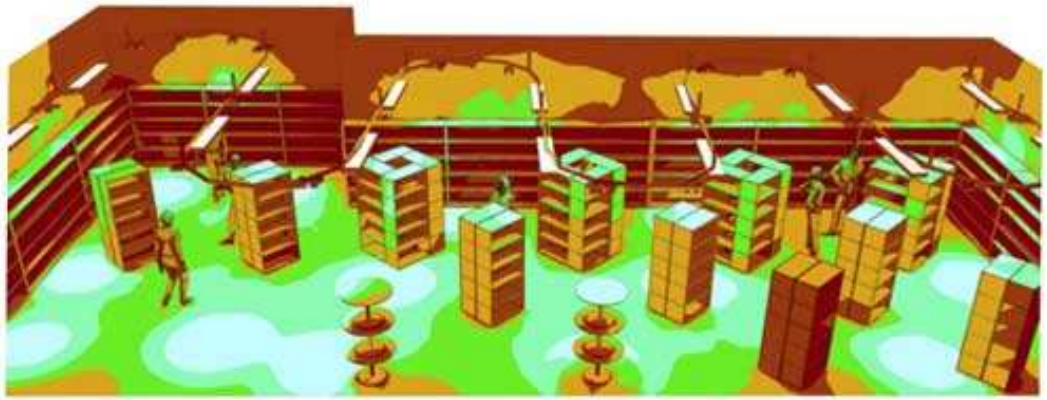
Real pictures:

Student union rotunda with view of campus courtyard.

Computer graphics:







Examples of lighting design

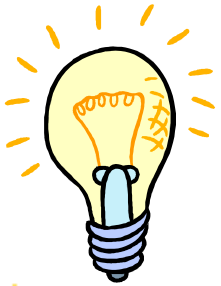
Purpose of Lighting

- Two main concerns of lighting design:
  - Provide *illumination* for people to use a space and to see well enough to FUNCTION at their designated tasks
  - Create *perception* of the space(s) or form(s) so that the designer's CONCEPT is communicated and/or felt
- Effect of lighting
  - On architecture (defines space & shows form)
  - On interior design (reveals texture & colour)

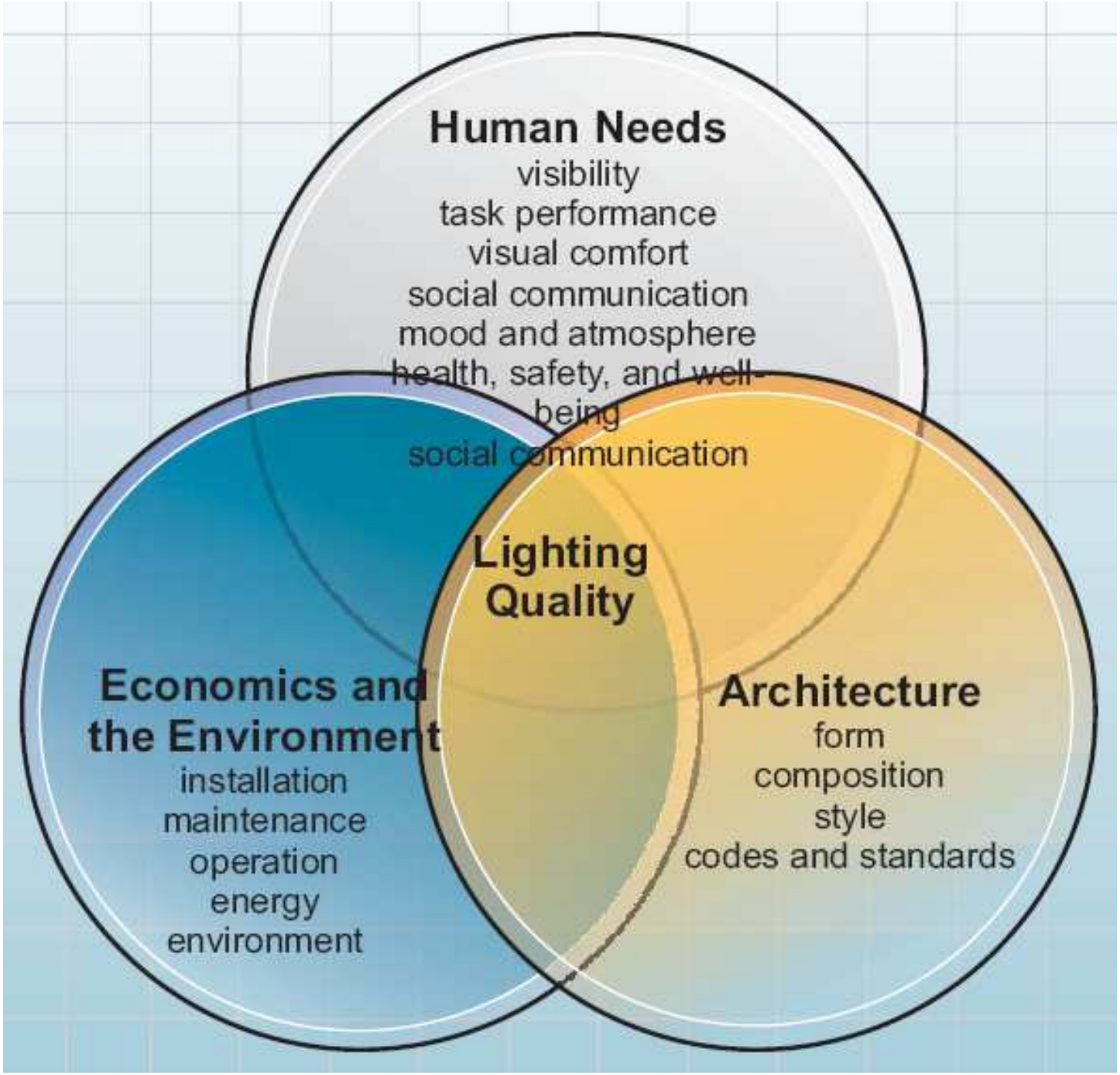
Purpose of Lighting

- The complex and temporal nature of lighting is one of the least understood of its many variables. Because of this complexity, lighting design can be one of the most creative areas of all of architecture
  - Light defines space, reveals texture, shows form, indicates scale, separates functions, creates mood
  - Good lighting makes a building look and work the way the architect intended at all hours of day and night

Purpose of Lighting



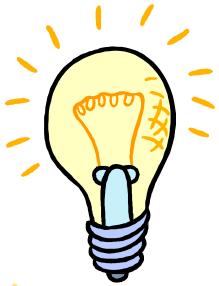
- Lighting contributes to the character, to the desired attitude toward form and space, and to the effective functioning of that space
  - Lighting is dynamic. Change the lighting and the world around us changes
  - Light can make or break a space both functionally and aesthetically



Overlapping lighting issues

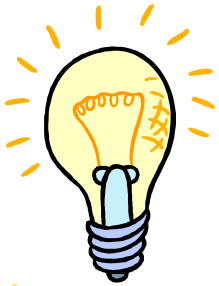
(Source: IESNA Lighting Handbook, 9th ed.)

Purpose of Lighting



- Three main functions of lighting:
  - Ensure the safety of people
  - Facilitate the performance of visual tasks
  - Aid the creation of an appropriate visual environment

Purpose of Lighting



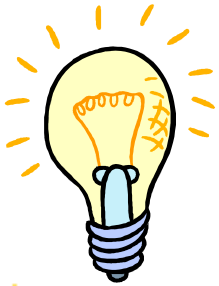
- Two sources of light:
  - Natural sources of light (daylight)
    - People prefer daylight to “windowless” rooms
    - Windows provide a view & connection to outdoor
  - Artificial or man-made (electric light)
- Electric lighting and the daylighting should be complementary to ensure
  - Efficient use of energy
  - High quality lighting

Terminology

- *Lighting Quantity*
  - Setting criterion illumination level
  - Illumination level based on light source spectrum
- *Lighting Quality*
  - Light distribution (e.g. task & ambient lighting)
  - Space and workplace considerations (e.g. daylight integration and control)
  - Colour appearance, flicker, glare
  - Modelling of faces/objects, highlights

(Video: Quality of light and lighting (3:27) http://www.youtube.com/watch?v=xUkxrKlPg48)

Terminology



- Lighting terminology
  - Luminous flux 光通量 (lumen, lm), Φ

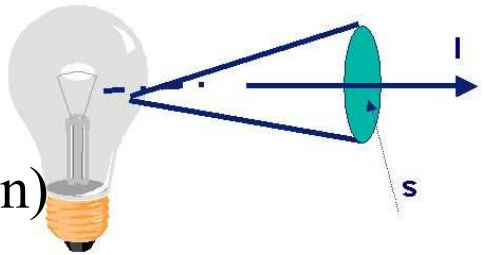
Radiation value

    - Light power emitted by a source or received by a surface (radiant flux according to the spectral sensitivity of the human eye)
    - A candle flame generates about 12 lumens
    - Fluorescent lamp 32W = 3,300 lumens

  - Luminous intensity 光強 (candela, cd), *I*

Sender-side value

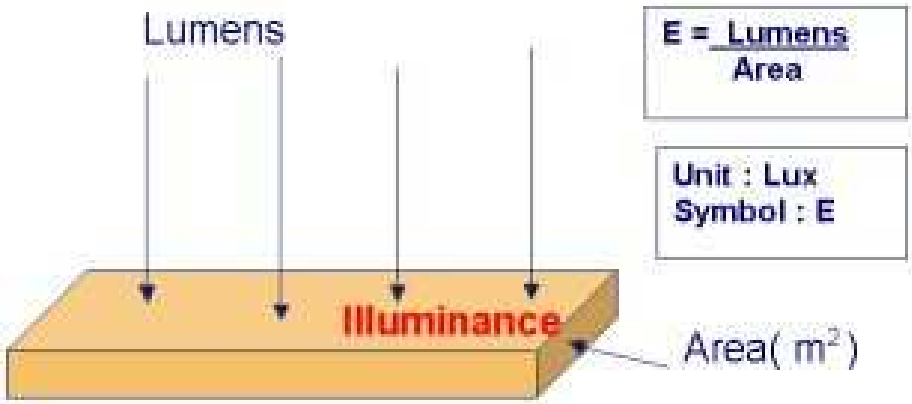
    - Luminous flux per unit solid angle in the direction in question, $I = d\Phi / d\omega$ (ω = solid angle, in steradian)



  - Illuminance 照明度 (lm/m^2, or lux), *E*

Recipient-side value

    - Light energy arriving at a real surface, $E = d\Phi / dA$ (A = receiving surface area) (“lumen per unit area”)



Summer, at noon, under a cloudiness sky	100 000 lux
Ditto, but in the shade	10 000 lux
In the open under a heavily-overcast sky	5000 lux
Artificial light, in a well-lit office	1000 lux
Artificial light, average living-room	100lux
Street lighting	5-30 lux
Full moon, on a clear night	0,25 lux

Practical examples of illuminance

(Source: Philips Lighting, http://www.lighting.philips.co.in)

Terminology

- Lighting terminology*
  - Luminance 亮度 (cd/m^2), L

Sender-side value

- Luminous flux density (I) leaving a projected surface in a particular direction (often called "brightness")
- $L = I / dA.\cos\theta = (d\Phi/d\omega) / dA.\cos\theta$
  - $d\omega$ = solid angle containing the given direction
  - dA = area of a section of that beam (the source side) containing the given point
  - θ = the angle between the normal to that section and the direction of the beam

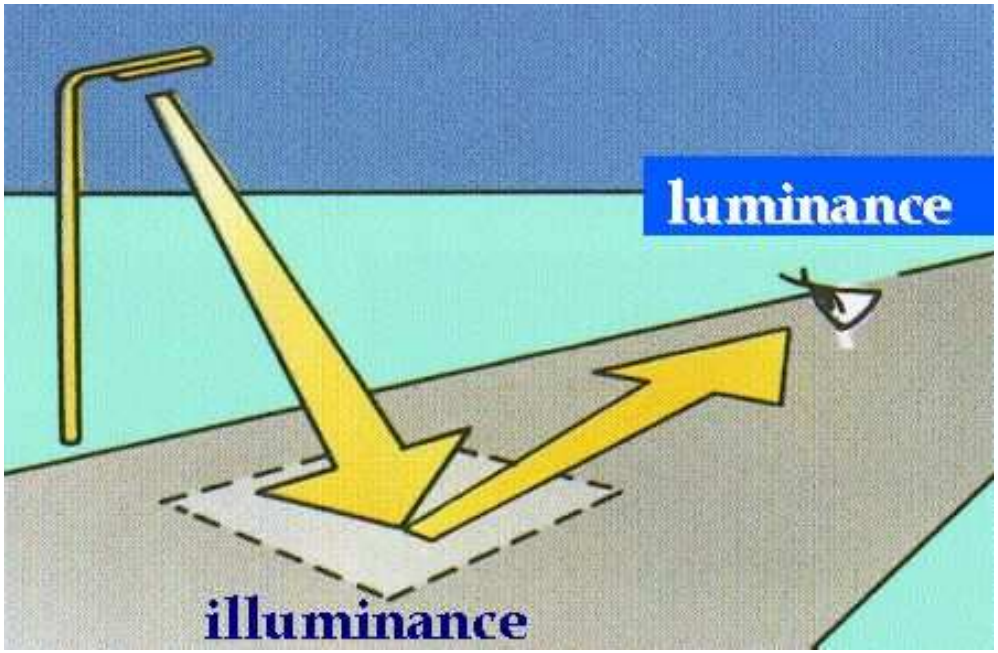
(* See also http://hyperphysics.phy-astr.gsu.edu/hbase/vision/photomcon.html)

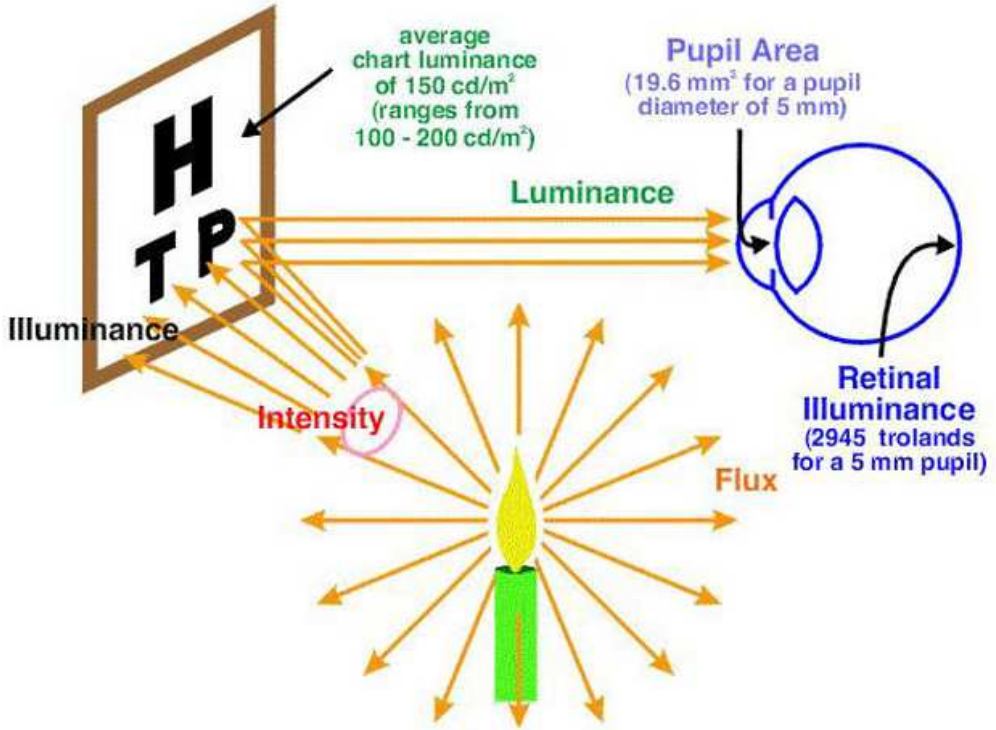
Surface of the sun	1 650 000 000 cd/m^2
Filament of a clear incandescent lamp	7 000 000 cd/m^2
Bulb of an 'Argenta' incandescent lamp	200 000 cd/m^2
Fluorescent lamp	5000 -15 000 cd/m^2
Surface of the full moon	2500 cd/m^2
Sun-lit beach	15 000 cd/m^2
White paper (reflectance 0,8) under 400 lux	100 cd/m^2
Grey paper (reflectance 0,4) under 400 lux	50 cd/m^2
Black paper (reflectance 0,04) under 400 lux	5 cd/m^2
Road surface under artificial lighting	0,5 - 2 cd/m^2

Practical examples of luminance

(Source: Philips Lighting, http://www.lighting.philips.co.in)

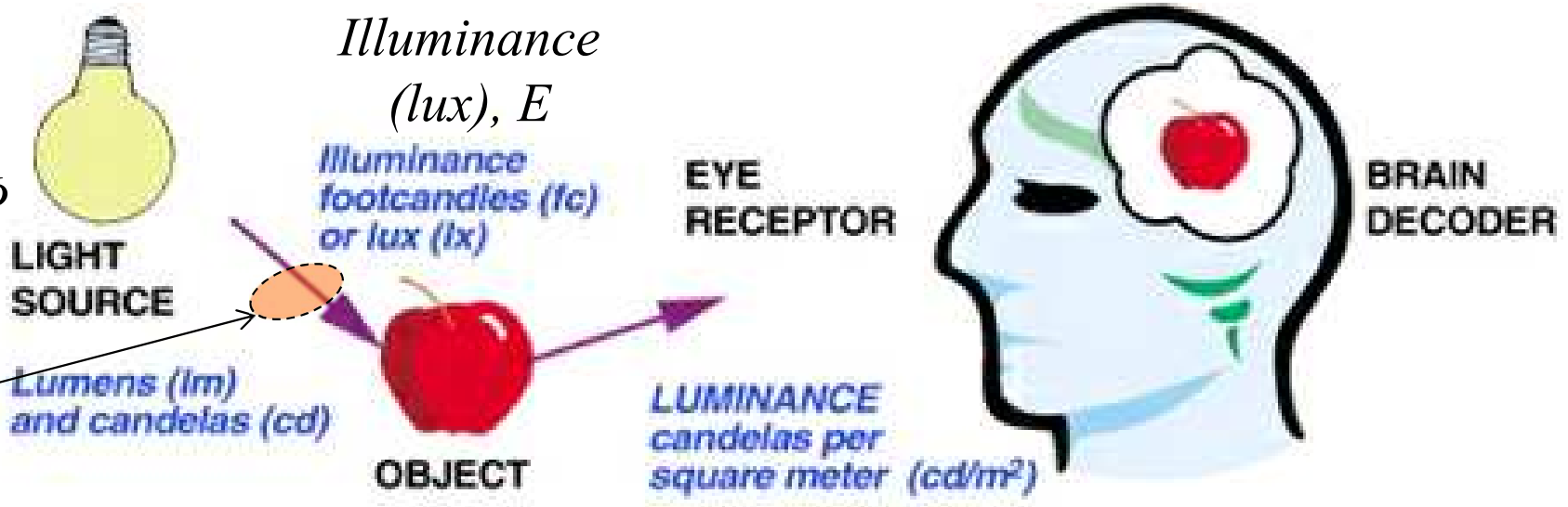
Illuminance and luminance (Source: Lessons in Lighting, http://www.lightolier.com)





Luminous flux (lm), Φ

Luminous intensity (cd), I



Illuminance (lux), E

Luminance (cd/m²), L

Terminology

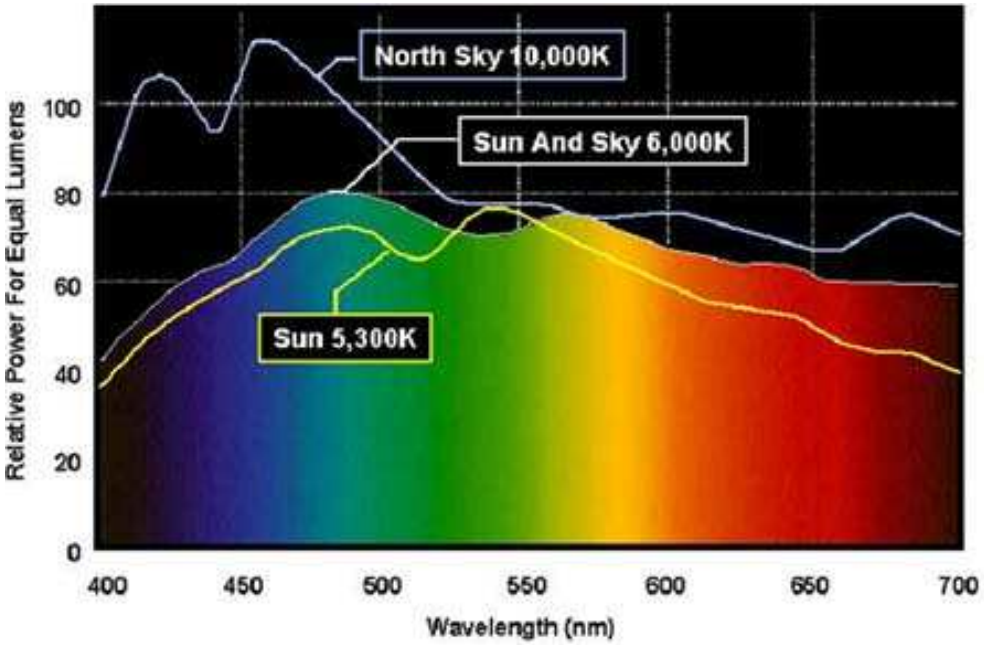
- Lighting terminology
  - Luminous efficacy of a source (lm/W), η
    - Ratio between the luminous flux emitted and the power consumed by the source *
  - Spectral power distribution (SPD) curves**
    - Curves to show the visual profile and colour characteristics of a light source
    - Plot of relative power emitted in the different regions of the spectrum

(* See also http://en.wikipedia.org/wiki/Luminous_efficacy)

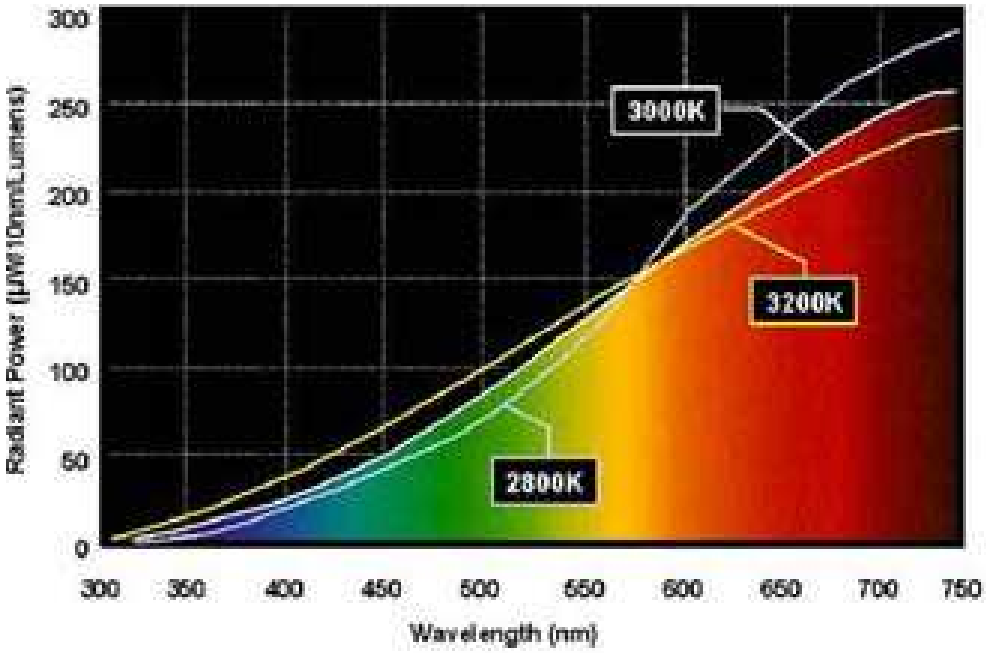
(**See http://www.gelighting.com/na/business_lighting/spectral_power_distribution_curves/)

Spectral power distribution (SPD) (Source: GE Lighting, http://www.gelighting.com)

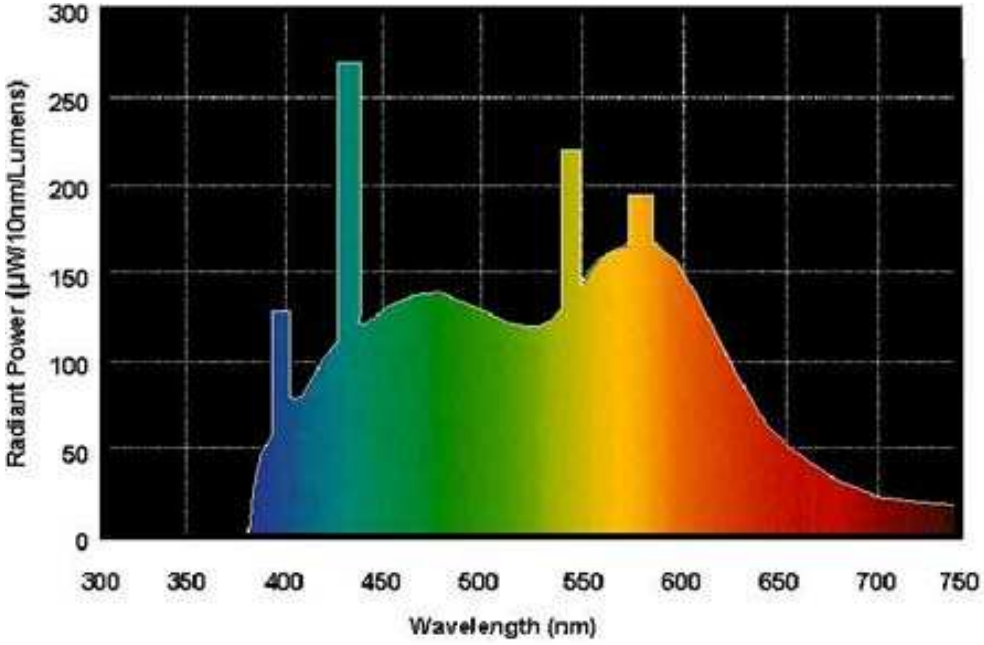
Outdoor daylight



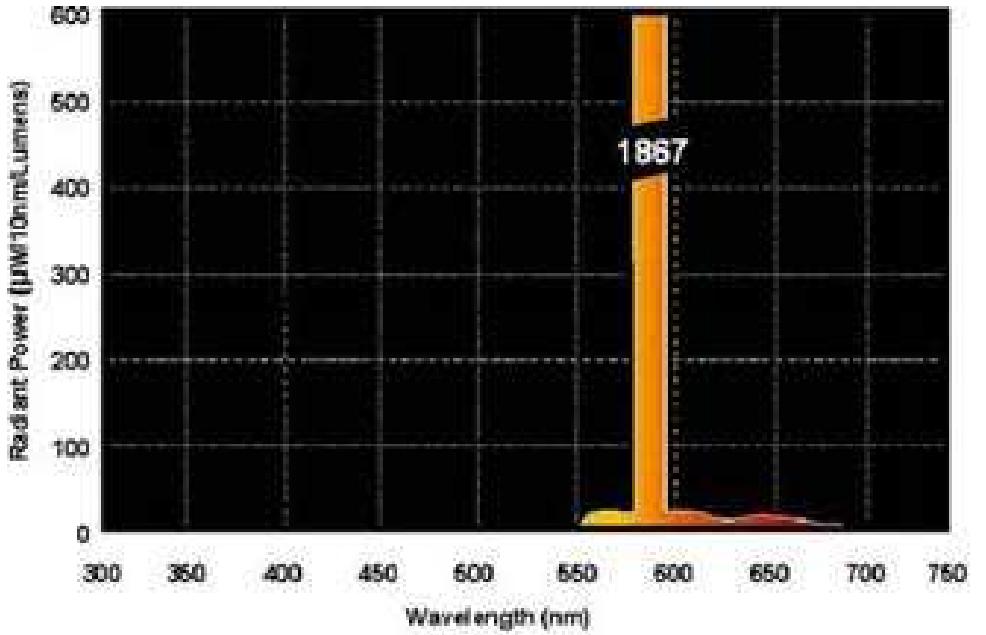
Incandescent



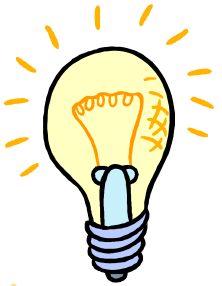
Fluorescent lamp (Daylight)



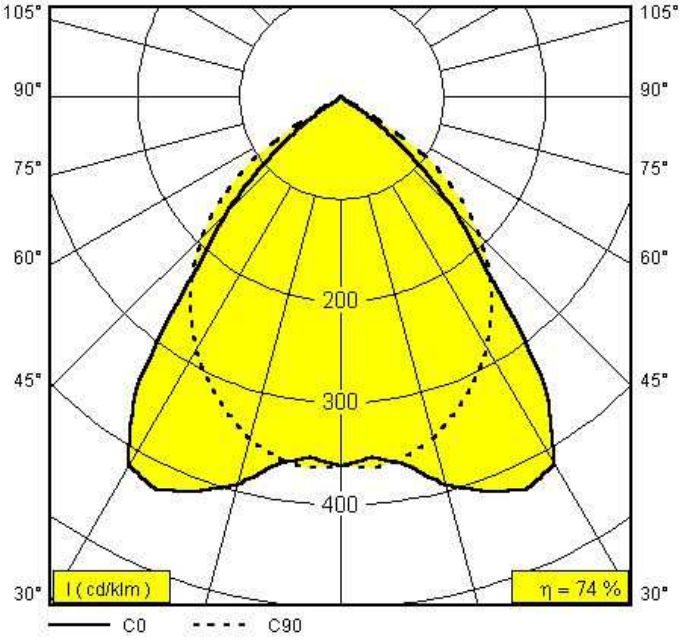
Low pressure sodium (LPS)



Terminology

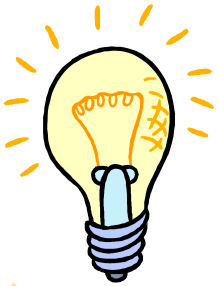


- Lighting terminology
  - Photometric data
    - Indicate how a particular lamp or luminaire “sends out” light – light distribution in terms of intensity and direction
  - Glare
    - Visual discomfort/disability caused by excessive brightness or extreme contrast *
    - Glare index or limiting glare rating

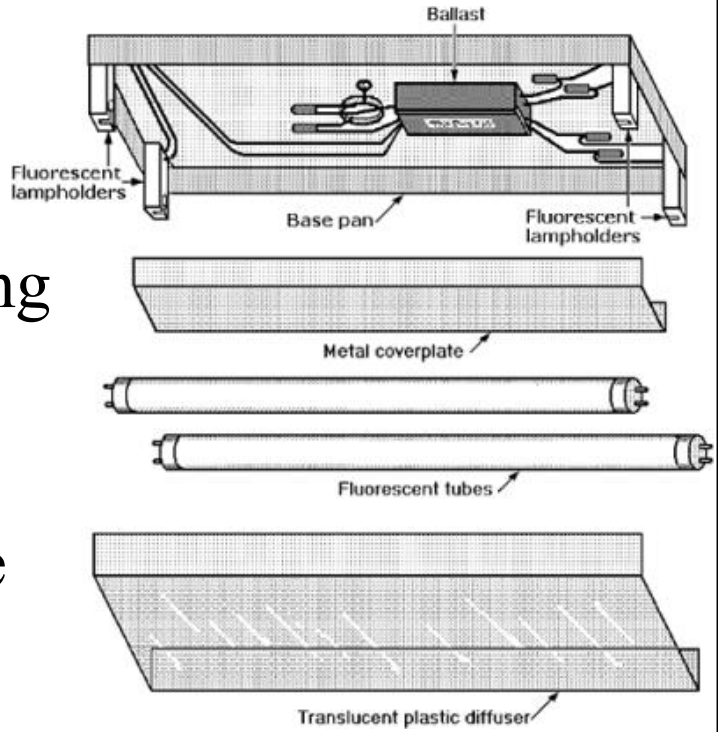


(* See also http://en.wikipedia.org/wiki/Glare_(vision))

System Overview



- Anatomy of a “lighting system”
  - Lighting components
    - Power source
    - Power controller: switching/dimming
    - Power regulators: ballasts
    - Light source: lamp
    - Optical control: luminaire or fixture
  - Environmental components
    - Room finishes: reflectances and texture
    - Spatial envelope: room boundaries
    - Fenestrations: windows and skylights



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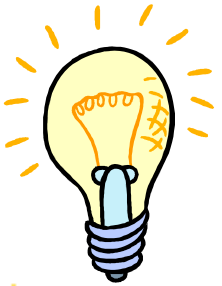
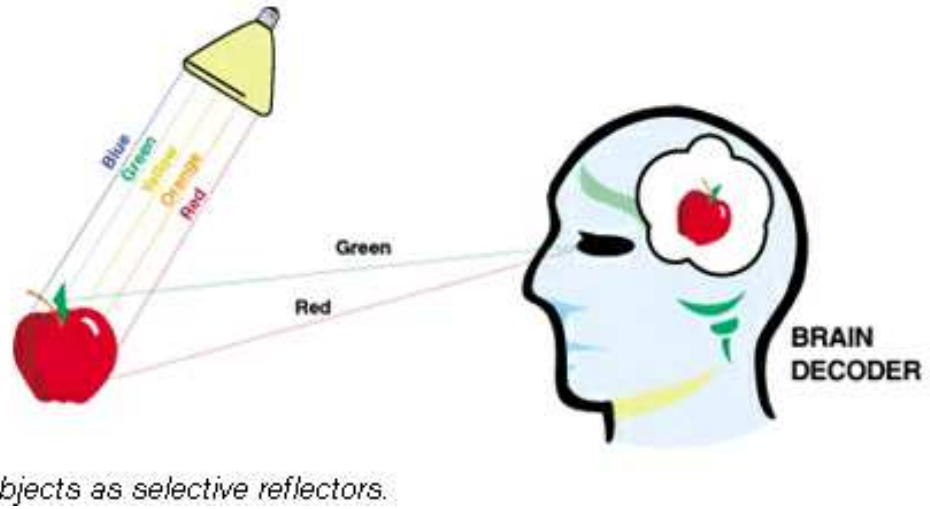


- Anatomy of a “lighting system” (cont’d)
  - Human components
    - Visual receiver: Eye
    - Visual acuity: Vision
    - Visual decoder: Brain
  - Task components
    - Task finishes: texture, colour, reflectance, specularity
    - Task size: object size
    - Task brightness: luminance
    - Contrast: brightness ratios
    - Speed and accuracy: time



Objects as selective reflectors.

Lighting Analysis Tools

- Basic practice of illuminating engineering
  - Hand calculations, e.g. Lumen method
    - Predict the average illuminance level in a room
    - Also known as zonal cavity calculation
    - Typical templates for spreadsheet programs or short routines built into handheld computers
  - Basic point-by-point lighting computer programs
    - Determine light levels at specific locations in a space
    - Predict brightness of room surfaces (e.g. by gray-scale plots and isolux plots

Lighting Analysis Tools

- Basic practice of illuminating engineering (cont'd)
  - Advanced lighting programs, e.g. radiosity & ray-tracing programs ➔ semi-photorealistic images
    - Extreme accuracy in spaces of complex geometry
  - Specialty calculations, e.g. exterior lighting, daylighting, energy simulation, economic analysis
  - Scale models (usually by architects)
  - Lighting audits, retrofit assessment

Further Reading

- Video Presentation:
  - Lighting terminology (5:50)
    http://www.youtube.com/watch?v=9nPIzyV1mW0
  - Luminous flux (1:22)
    http://www.youtube.com/watch?v=V_bZhzCpCcs
  - Luminous intensity (1:00)
    http://www.youtube.com/watch?v=78cxI5LhTlY
  - Luminance and illuminance (2:07)
    http://www.youtube.com/watch?v=2D8wtLRGKYo
  - Photometrics (5:59)
    http://www.youtube.com/watch?v=hByR2V4qyq8

Further Reading

- Basics of Light and Lighting (Philips Lighting) [PDF]
  - http://ibse.hk/SBS5312/basics_of_light_and_lighting.pdf
- Light@Work, by OSRAM [PDF]
  - http://ibse.hk/SBS5312/Light_At_Work.pdf
- Lighting theory essentials (Philips Lighting)
  - http://www.lighting.philips.com/main/education/lighting-university/lighting-university-browser/course/lighting-theory-essentials
- Lighting Design Considerations http://www.lumitronlighting.com/lighting_nowledge/Lighting%20design%20considerations.pdf

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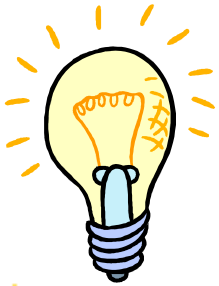

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