

Lecture 28 illumination Systems



Ahmet Bingül

Gaziantep University Department of Optical Engineering

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Introduction

Illumination optics is required applications:

- Microscopes
- Projection systems
- Machine vision systems
- Industrial lighting
- Automotive lighting systems
- Tunel/Street lighting
- Stadium lighting
- Indoor/Outdoor lighting
- PAPI (Precision approach path indicator)



LIGHT SOURCES

Light Sources: maybe natural or artificial

Light sources have a wide range of types, shapes, and sizes, and the choice of the design of the illumination optics is very dependent on the source.

- Sunlight, skylight
- Fire
- Incandecent sources
 - Blackbody sources
 - Tungsten flament
- Halogen / Discharge lamps (Gas Filled Tubes)
 - Monochromatic and spectral sources
 - > High-intensity sources
- Semiconductor light-emitting diodes (LEDs)
- Coherent source (laser)
- Point source (this is abstract light source)



Point Source

- There are two types and sources of light: point source and extended source.
- A point source has negligible extent, distinguishing it from other source geometries.



Many sources are called point sources because in **mathematical modeling**, these sources can usually be approximated as a mathematical point **to simplify analysis**. Generally a source of light can be considered a point source if the resolution of the imaging instrument is too low to resolve its **apparent size**.

Day Light: combination of sunlight and skylight





Tungsten Bulb

Tungsten Halogen Lamb is an incandescent (=akkor) lamp that has a small amount of a halogen such as iodine or bromine added. Tungstem Lambs are used in

monochromators.







Discharge Lamps (Gas Filled Tubes)

Gas-discharge lamps are a family of artificial light sources that generate light by sending an electric discharge through an ionized gas, a plasma, (argon , neon , krypton , xenon, CO2, . . .) Each gas, depending on its atomic structure, emits <u>certain wavelengths.</u> The emission spectrum determines the color of the light from the lamp.

















LEDs in ILLUMINATION

Admittedly, illumination is one of the main requirements of people. LED (Light Emitting Diode) is an energy-saving light source providing high light efficiency and long life time. Nowadays, many cities across North America, China and Europe start to prefer LED for internal/external/street illumination. In Türkiye, both government politics and companies working many years on the illumination sector foresee that all illumination systems are going to be based on LEDs in the near future.







BlackBody

Hot objects emits thermal radiation Intensity of blackbody radiation:



 $\lambda_{\rm max}T = 0.0029 \,{\rm m}\cdot{\rm K}$





LIGHT PIPES

Light pipes are commonly used as light homogenization components in illumination

Light pipes can be

- hollow structures with reflective inside surfaces
- solid structures inside of which the light is totally internally reflected







shapes that are good spatial homogenizers of light at the output shapes that are bad spatial homogenizers of light at the output





PROJECTOR DESIGN

Projector System

In this example application, we will implement a projector optical system using single LED.

As an example, this kind of system may be used in automotive lighting to project logo or signals of the car to the ground.







Abbe and Köhler Illumination

There are two classic approaches to the design of illumination systems. Most modern illumination system designs are modifications of one of these basic concepts.

Abbe Illumination

- Project the light source directly onto the target object.
- This method is applied when the light source meets the system's uniformity requirements.



Köhler Illumination

In instances involving a small yet intensely **non-uniform source**, like an arc, a filament lamp or LED, achieving uniform brightness at the image can be realized through Köhler illumination.



Logo Projector System Overview



Lambertian Source / Reflector

Lambert's cosine law says that the observed radiant intensity or luminous intensity from an ideal diffusely reflecting surface or ideal diffuse radiator is directly proportional to the cosine of the angle θ between the observer's line of sight and the surface normal; $\mathbf{I} = \mathbf{I}_0 \cos \theta$.

Lambertian reflectance is the property that defines an ideal "matte" or diffusely reflecting surface.



Example: Effect of Coating/Scatering on Mirror Surface



Oujiu Li



Freeform Optics

Freeform optics refers to optical components (lenses or mirrors) whose surfaces do not have traditional rotational symmetry (such as spherical or aspherical surfaces).

Instead, these surfaces can have complex, irregular shapes tailored to specific optical functions, which allows for highly flexible and compact optical system designs.

Applications:

illumination:LED collimator, uniform illumination.Automotive:car headlight, head-up displays.Aerospace/defense:High-performance imaging systems.Medical devices:Compact diagnostic and imaging tools.Consumer electronics:Cameras in smartphones.





Compound Parabolic Concentrator (reflector)

CPCs are designed to efficiently collect and concentrate distant light sources. CPSs can be used for any applications requiring condensing of a divergent light source.

- solar energy collection
- wireless communication
- biomedical and defense research
- LiDAR

See also: Edmund Optics



Freeform TIR Lens Design for LED Collimation

Compnents: CPC, Lens, Source Ray, Detector. Download the zemax file.

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Freeform Lens Design for Uniform Circular illumination

- 1. We will follow the Chapter 3 of the book.
- 2. You can download the Matlab program named freeform_circular.m from the course web page.
- 3. In the following link we have some cad files: http://www1.gantep.edu.tr/~bingul/opac202/cad/



Freeform Optics for LED Packages and Applications



GG Chemical Industry Press

WILEY