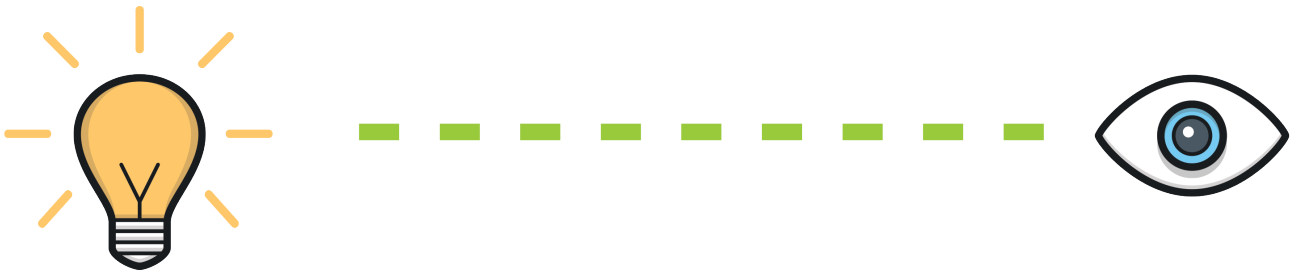
LUMITEX™

The Ultimate Guide to

Light Measurement



Introduction

This new guide will show you everything you need to know about measurement of light.

It's important to understand the different terms used to characterize light. From the measurement of light in the electromagnetic spectrum to understanding perceived brightness to the human eye, light intensity and what tools can be used to measure light.

Let's dive in...

Contents

Chapter 1

Units of Light
Common Light Measurement Terms

There are different units for measuring light used by the lighting industry.

Here are a few common light measurement terms:

Flux - originated from the Latin word 'Fluxus' that means flow

In lighting, flux (process of flowing), you need to consider **watts (W)** (energy used) versus **lumens (lm)** (brightness). Or electricity consumption vs. light output. Lumens are weighted for human perception where watts is not.

- **Lumen(lm)** - The SI unit of luminous flux. It is a unit of light flow.
- **Watt(W)** - The unit of measuring electrical power. It is a radiometric measurement.

Intensity of Light - quantity of visible light that is emitted in unit time per unit solid angle

- **Candela (cd)** The SI base unit of luminous intensity. It is a unit of luminous intensity of a light source in a definitive direction. 1 lumen = 1 candela x steradian (the SI unit of solid angle).

Illuminance - the amount of luminous flux per unit area

- **Lux (lx)** - The SI unit of illuminance and luminous emittance. One lux is equal to one lumen per square meter - formula: Lux - Lm/m^2
- **Footcandle** - is a non - SI unit of light intensity. While lux is lm/m^2, a footcandle is lm/ft^2.

What is Illuminance?

source: The [Audiopedia - Illuminance]

Luminance - the intensity of light from a surface per unit area in a given direction

- cd/m^2
- 1 cd/m^2 = 1 nit (**Nit** (nt) - A name given for a unit of luminance)

For an easy understanding, think of a lamp that produces light.

- That light is measured in lumens (measure of light intensity)
- The light will fall on a surface which is expressed as lux
- The human eye will see this visual in terms of brightness, or luminance that is measured in candelas

Chapter 2

Radiometry
How Much Light There Is

What is Radiometry

Overall, radiometry is the science of measuring electromagnetic radiation. In regards to optics, it refers to the detection and measurement of light waves in the optical portion the electro-magnetic spectrum (infrared, visible, and ultraviolet). It includes characterizing the distribution of the radiation's absolute power.

Why is Radiometry Important

Radiometry encompasses a wide variety of needs for sensing and measuring light.

Some Common Applications:

Common Applications of Radiometry	
Astrophysics	Night-vision Devices
Clinical medicine	Photobiology
Colorimetry	Photochemistry
Diagnostic Medicine	Solar Energy
Illumination Engineering	Television Systems
Meteorology	

4 Conventionally Used Geometric Descriptions in Radiometry

Radiant flux is the fundamental unit in radiometry.

1. Radiant flux /power - expressed in watts, it can be defined as the total optical power of a light source. It can also be defined as the rate of flow of radiant energy. You can think of it as - the total amount of light emitted from a light bulb.

2. Radiant intensity - also measured in watts, radiant intensity is the amount of flux emitted through a known solid angle.

3. Irradiance - Measured in Watt/square meter, irradiance is the measurement of radiant flux on a known surface area.

4. Radiance - Measured in Watt/square meter Steradian, radiance is the measure of radiant intensity emitted from a unit area of a source.

Chapter 3

Photometry
How You See Light (Visible Light)

What is Photometry

Photometry is a subset of radiometry that only applies to the visible portion of the electromagnetic spectrum. While radiometry focuses on measuring radiant energy in terms of absolute power, photometry takes into account the response of the human eye and focuses on measuring light in terms of perceived brightness.

Photometry is the "science of the measurement of light intensity, where "light" refers to the total integrated range of radiation to which the eye is sensitive. It is distinguished from radiometry in which each separate wavelength in the electromagnetic spectrum is detected and measured, including the ultraviolet and infrared." Photometry. In EDU.photonics.com/Photometry: The Answer to How Light is Perceived Retrieved from https://www.photonics.com/a25119/Photometry_The_Answer_to_How_Light_Is_Perceived

Why is Photometry Important

Photometry measures visible light from a person's perspective.

Common Photometry Applications:

As with radiometry, applications are also diverse. It is used in a number of industries to test the intensity of light produced by displays, instrument panels, night-vision devices, and more.

The basic unit of photometry is the lumen. Photometry consists of four basic concepts.

1. Luminous flux - Measured in lumens, luminous flux is the measurement of total perceived power emitted in all directions by a light source.

2. Luminous intensity - Measured in candela, it is the amount of light emitted by a source in a particular direction.

3. Illuminance - Measured in lumens per unit area, illuminance refers to the amount of light incident on a surface. Illuminance can also be referred to in foot-candle.

4. Luminance - Measured in candela per square meter or nit, luminance is the total light emitted or reflected from a surface in a given direction. It indicates how bright we perceive the result of the interaction of the incident light and the surface.

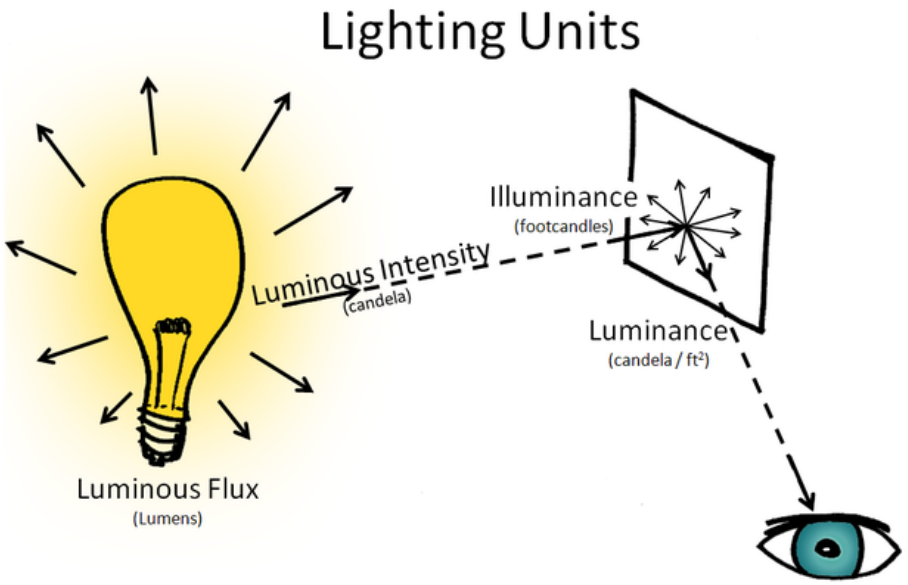


image credit: J.C. Walker, Light Sources - Technology and Applications [CC Attribution-ShareAlike 3.0]

Chapter 4

Spectrometry
Measuring Wavelength

Spectrometry is known for the science and utilization of spectrometers for measurement and analysis. It is the study of interactions between light and matter, and the reactions and measurements of radiation intensity and wavelength.

The image below shows a diagram of how spectrometry is used to analyze a sample. The sample is shown in Step 2. Spectrometry can also be used just to analyze the wavelengths present in a given light source. In this instance, there would be no sample between the source and diffraction grating.

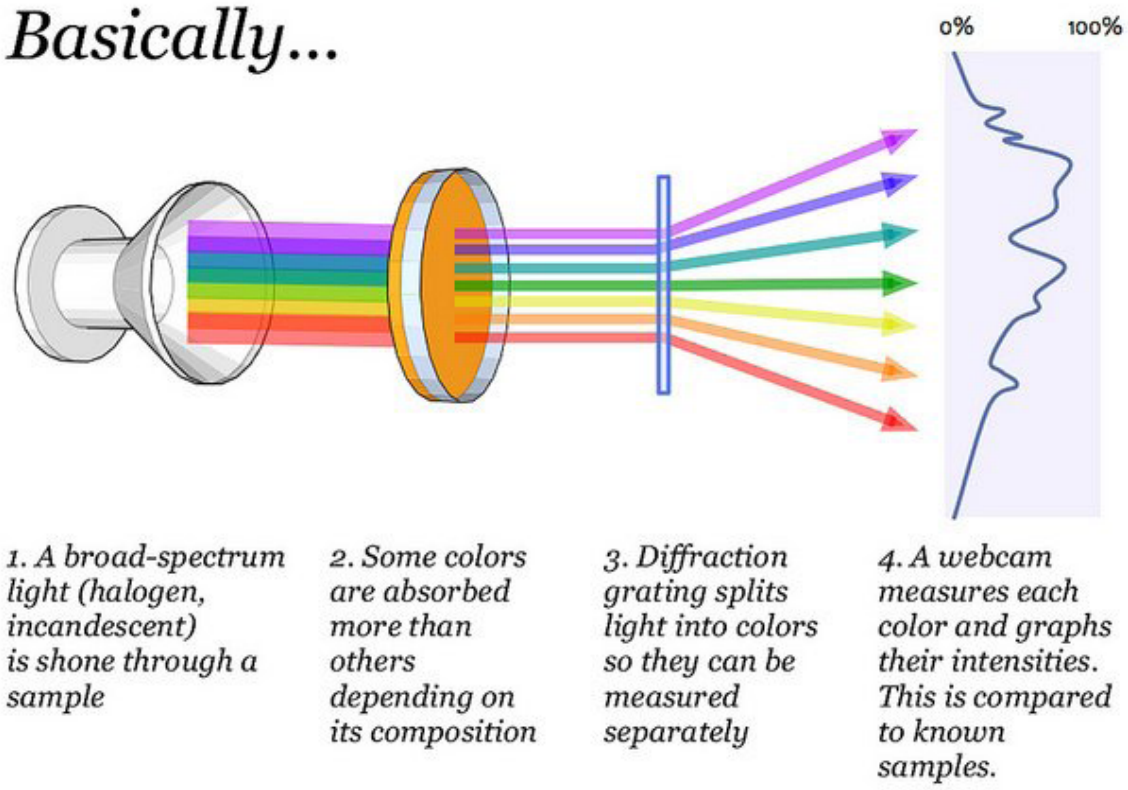


image credit: By publiclaboratory Spectrometry diagram [CC BY 2.0] from flickr

Spectrometry uses:

In an article written by ATA Scientific Instruments, What is Spectrometry and What is it Used For, they detail modern ways we use spectroscopy:

- In astronomy, we can use the unique spectra to identify the chemical makeup of objects in space.
- We can also use it to identify properties about space objects: chiefly their temperature, as well as their velocity.
- It has applications in metabolite screening and for analyzing and improving the structure of drugs.

The biomedical use of light consists of diagnostic and therapeutic applications. Read more on Spectroscopy in Biomedical Services.

Spectroradiometry is the "measurement of light energy at individual wavelengths within the electromagnetic spectrum. It can be measured over the entire spectrum or within a specific band of wavelengths."

Spectroradiometry. In KonicaMinolta.us: Radiometry, Spectroradiometry and Photometry Retrieved from: https://sensing.konicaminolta.us/learning-center/light-measurement/radiometry-spectroradiometry-photometry/

Two basic concepts of Spectroradiometry are:

> **Spectral Radiance** - is the radiance of a surface per unit frequency or wavelength. The SI units for spectral radiance is Watt/square meter Steradian nanometer.

Spectral Irradiance - is the irradiance of a surface per unit frequency or wavelength. The SI units for spectral irradiance is Watt/cubic meter.

Chapter 5

How to Measure Light Intensity

Calculating the intensity of light depends on the light source and the direction in which it radiates light. The amount of light falling on a surface is known as illuminance and is measured in lux.

Sciencing wrote a step by step article / experiment on How to Calculate Light Intensity with the intensity of light around a bulb that radiates light equally in all directions. The conclusion detailed that "the light intensity at your point on the sphere is equal to the number of watts that the bulb radiates divided by the surface area of the sphere." The full calculations can be found here.

In photometry, **luminous intensity is a measure of the radiant power emitted by an object in a particular direction and is dependent on the wavelength of light being emitted**.

What matters the most in terms of **measuring light intensity is the actual number of lumens falling on a particular surface**.

Measuring Light Levels

As noted above, flux is the total light output. With watts referring to absolute power and lumens being weighted for human perception.

What's the Difference Between Luminance and Illuminance

“Luminance is the amount of light reflected off the surface being Illuminated”.

Illuminance is measured as the amount of light striking a surface.

Luminance is what we measure off of the surface the light is striking.

Top Light Co said it the best...

Think of it like this – IL-Luminance, IL, I = Incident Light. Illuminance is measuring the incident light. Luminance is what’s leaving the surface – L = leaving. Illuminance is measuring incident, luminance is measuring what’s leaving.

Chapter 6

What Tools Are Used to Measure Light

1 Photometer

A photometer is an instrument that measures light intensity. It can be defined as an instrument that measures visible light.

Two types of photometers are:

1. **Luminance meters** - determine visible energy output of a light source

Luminance measurements are used for products such as traffic lights and automobile tail lights.

2. **Illuminance meters** - measure visible energy falling on an object's surface.

Luminance Meters and Colorimeters

2 Integrating Sphere

"An integrating sphere collects electromagnetic radiation from a source completely external to the optical device, usually for flux measurement or optical attenuation."

Integrating Sphere Fundamentals and Applications

3 Spectrometer

"The basic function of a spectrometer is to take in light, break it into its spectral components, digitize the signal as a function of wavelength, and read it out and display it through a computer."

Spectrometer

4 Light Meter

A light meter is a device used to measure light levels. Light level is the amount of light measured in a plane.

Conclusion

There are many terms and technology when it comes to the power of light and light measurement. It is unique to understand how they all come together.

Understanding the measurement of light helps us, as a lighting solutions provider, meet the brightness and uniformity requirements of your specific applications.