

Hello everyone, the tutor for lighting design part in module Arc 311 Environmental Design 3.

The assessment for ARC 311 includes two types.

For artificial lighting design part, you should submit a poster through electronic way in VITAL. The deadline will be 12 March 2021.

And this part has 30% of total module marks.

Other parts include acoustics and building service lectures which will be assessed through written exam. The marks is around 70% of total module marks.

For lighting design part, it includes 4 subsections: 1 describing light, 2 making light, 3 lighting design principles, 4 lighting museums and arts galleries.

Today is the first section: describing light.

Artificial lighting and sustainable design.

Worldwide electrical lighting consume around 19% of total global electricity.

Producing 1900 Mt of CO<sub>2</sub> per year equivalent to 70% of the emissions from all the world's cars.

We can tell it's a big number.

Lighting accounts for around 15% of energy cost in homes and around 25% in commercial buildings.

Light is routinely supplied to spaces. If no one is a present, and over lighting occurs even though visual functions are insensitive to light levels beyond certain thresholds.

The availability of powerful and affordable artificial lighting has allowed designers and architects to create deep plan.

This deep plan can be dark boxes, where are the best source of light that means daylight, cannot reach.

Here are two cases. The left is atrium space dominated by daylighting; the right side is office room has artificial lighting and daylighting together.

Artificial lighting: basic principles.

1: light for visual functions.

Illumination of task area to meet standards.

Second, glare free and convenient.

Light for biological and wellbeing effects. Supporting people sick and in rhythm to keep health and wellbeing.

Also, it can stimulate or make people feel relaxed.

Light for emotional perceptions. Lighting can enhance architecture and enhance architectural levels or other qualities.

Also, it can create sense and effects indoor or outdoor.

Light for sustainability.

Balancing light quality with energy use. Integrating or controlling artificial and natural light that's really important task in the building.

What is a light, physically?

Light is a simply a small part of the electromagnetic spectrum. According to this wavelength we can find that: this area is visible wavelength, i.e., the light.

What is the light?

Based on these wavelengths, we found visible light has a wavelength from 380NM to 780NM.

So, look at this, the response of the human eye to a small range of wavelengths in the electromagnetic spectrum.

The eye varies in sensitivity with the colour of the light, the colour of the light means the different wavelengths. From here, this picture, we can find visible wavelengths.

Why did the human eye adapt to be most sensitive to these wavelengths?

Because they are the most 'energy' found in the solar spectrum.

According to these curves we found visible part just located at the peak area that most energy, higher level energy. We call this part as a visible spectrum vision.

More than 80% of the information we receive from the physical world passes through our eyes.

The physical world is captured by the eye through different approaches.

First, there is: the light enters through the pupil.

Second, the light is focused by a lens onto the retina at the back of the eye.

Retina will convert the light into signals. These signals will be transmitted to and interpreted by the brain.

Human eye.

Retina consists of light sensitive nerve endings called rods and cones.

According to these pictures we can find different rods and cones. They are cells.

Around 120 million rods and 6-7 million cones.

Rods spread fairly evenly over the retina.

Cones concentrated in the center of the retina.

Eye and brain: rods and cones.

From this table we can find the properties of rods and cones.

The key issues about the two types of cells:

Rods highly light sensitive help to determine rough shapes and movement in low light level. That is at night.

Cones can help distinguish colours and fine details, which can be used in daytime.

Types of vision.

First, photopic vision. Another name is the day vision.

Normal visual conditions cones take over completely.

Scotopic vision. Another name is the night vision.

At very lower lighting levels, rods take over completely.

Mesopic vision that happened when Dawn, dusk and under normal Street lighting condition.

We can tell that has very low lighting Level.

Intermediate lighting, condition. Rods + cones work together.

From here we can tell for the photopic vision we can see colour.

For Scotopic Vision. We cannot see colour. Only black and white.

Scotopic vision. We can see the colour. But for that colour, compared with the daytime, it has not achieved a proper quality. Looks not so good.

Eye and brain: Darkness adaptation.

According to the left curves we can find with a relatively higher lighting level, the cones are more sensitive there. With the relatively lower lighting level, the rods are more sensitive.

From the higher lighting level transferred to the lower lighting level, it may take time to adapt.

For an opposite way, the same things (adaptation) may happen.

This phenomenon can be called darkness adaptation.

From the 'bright' to 'dark' and from the 'dark' to 'bright', both may need adaptation.

Allowing enough time and space for adaptation is a major aim of good lighting design in museums, gallery's cinemas, etc.

Eye and Brain: Camera and analogy.

From this picture we can find some ideas there.

An analogy is sometimes drawn between the eye and a camera.

However, whereas a camera records what it sees the eye - brain system is driven to try and interpret what it observes.

This need for the eye-brain system to try and make sense of whatever it says is the basis of many optical illusions.

Here are two cases. The left side is a famous picture according to this illusion. From this picture we can tell in the middle there is a white triangle.

For the right side, similar, we found: So even in reality the rail length did not change. According to this picture we may find some differences found between two rails.

Here we can see two orange dots. They have the same size.

If we add something. Maybe this perception is changed.

Have you found the difference?

Here is a famous illusion case named rotating Snake.

Have you found some interesting parts?

Look at this centre cross. Have you found some interesting things happened?

If you are interested in such phenomena, you can check this web page to get more cases. Very interesting.

Lighting units.

We have four typical lighting units.

First is the luminous flux: the flow of light.

The 2<sup>nd</sup> is the luminous intensity: The flow of light in space.

The third is illuminance: The flow of light onto a surface.

The last is the luminance: The flow of light from a surface.

For the first one, luminance flux is the amount of light radiated by a light source.

Its unit is 'lm'.

Symbol is  $\phi$ , or F.

It is Often included in lamp specifications, in catalogues, data sheets, lamp packages, etc.

According to this product: Philips LED bulb, we can find this number: 806 lm.

This table shows several typical values according to this luminous flux.

We can find: The incandescent lamp (100 Watts) has 1200 lm;

For metal halide 2000 Watt, it has 200,000 lm. Very higher.

This table shows typical luminous flux values for LED, CFL, regular incandescent, halogens. Please check by yourself.

Second unit is the luminous intensity.

This unit is the quantity of light emitted per second in a specific direction.

Unit is candela, cd. Symbol is I.

This table shows the typical values according to the luminance intensity (candela). For one Candle, it is 1 cd. For a 100 Watts general lighting solution (GLS), (that is: incandescent lamp), it is around 110 cd.

The sun has a very high value.

Polar curves from a light source. For these polar curves, that unit is candela (cd).

**Illuminance:** The illuminance is amount of light or luminous flux falling on a unit area of surface.

The unit is Lux. You can use lux or lx. Both OK. Symbol is E.

1 lux = 1 lumen per square meter on the receiving surface.

A luminance is a dependent of the direction from which the luminance flux reaches the surface.

Illuminance also depends on lumen output of lamp, optical design of the luminanire, area on which it falls as well as shape and finish colours of the room surface.

This table shows typical value of illuminance Lux.

For overcast Sky, we found typical value is 5000 Lux.

For moonlight and Clear Sky, it is just 100 Lux.

**Luminance:** The luminance of a light emitting object or surface is the luminance intensity emitted per unit of an apparent area of that surface in a specific direction.

Unit is the candela per square meter. cd per m<sup>2</sup>.

Symbol is L.

How our eyes perceive luminance is called brightness.

This table shows typical value for this unit.

Visual performance.

This performance can be affected by the size of task, task detail, contrast of task, luminance of the task or illuminance on the task.

Disability glare. That is a visual discomfort problem.

Discomfort glare.

Adaptation time.

Chromaticity contrast.

For these curves we can find some interesting facts.

Horizontally it has several parameters including size, contrast, illuminance, etc.

For the parameter level below the threshold, nothing happened. The visual performance can be justified using value 0 to 100.

After achieving this threshold, these performance levels are increasing until achieve a certain level (100%) and keep this situation unchanged.

For several ranges according to different parameters: size, Contrast, illuminance, if we continue to increase the size or contrast or illuminance, the performance will go down.

This is very interesting trend according to the visual performance.

Relative importance of visual factors. If you increase the size of an object (timed by two), then to get the equivalent improvement in visual performance, you would need to increase contrast (timed by six) or increase illuminance (timed by 100).

You see, big difference.

To improve visibility increase, we can check these different sizes and contrasts.

Here is a real case. Please check by yourself.

Summary of lecture.

We perceive the world mainly through vision.

Lighting can play a big role in sustainable design.

Visual mechanisms differ with light levels or time of the day.

Visual performance is a complex mix of factors such as task object size, contrast, and illuminance.

Good lighting design needs to consider these factors in the context of the building's function, and its aesthetic visual environment.

This is the first lecture.

