

# The Right Lighting is Important ...

## The right lighting in the workplace

### 1. Learning objectives and system aspects

#### a. Learning objective and curriculum

Adequate lighting of the workplace is important for fatigue-free working and keeping the eyes healthy. Too much lighting of the workplace not only strains the eyes but also the environment in an unnecessary way. You can find out how all this is connected by yourself in some small investigations. You will learn a lot about light, light sources and programming.

#### b. Science background

In dealing with the topic, areas of physics, mathematics and computer science are addressed with a focus on The focus is on the elementary relationships between the light propagation of a lamp/LED. The necessity of informational knowledge combined with physical correlations is shown in order to use light energy in an environmentally friendly and health-promoting way. Basic knowledge of mathematics will be applied. Practical references to the correct choice of lighting equipment based on manufacturer's specifications such as lumen and beam angle and power are linked to health aspects.

#### c. Connection with Sustainability Development Goals

In this context, the goals 3, 7 and 13 should be mentioned: Maintaining health, careful use of energy and climate protection.

## 2. The actual activity

You need:

- several light sources, e.g. flashlight, LED lights, ceiling lighting,
- TI-Innovator Hub, TI-Nspire or compatible device

You learn:

- Light sources have different beam angles,
- Light sources require the correct distance according to the application,
- Light sources must be selected according to ecological parameters,
- Sunlight in your room does not always provide sufficient lighting,
- To use a simple luxmeter,
- LED lamps are not always beneficial to health
- Many LED lamps are not always energy saving

Before we can really start, some preparations have to be made. It is best to have three different light sources available. A table lamp, a flashlight, a ceiling lamp is possible. In the following we will take a closer look at the table lamp and a flashlight. But you can include as many different light sources as you like.

A very important note about your activities: Never look directly into the light source! This can damage your eyes.

## You start with the preparations:



Figure 1: TI-Innovator Hub

<https://education.ti.com/de/products/micro-controller/ti-innovator>

The TI-Innovator Hub has a light sensor. It is now necessary to learn more about this sensor together with the computer so that the various light sources can be examined. Connect the calculator to the hub with the included cable. The side with the printed A connects to the calculator. Switch on the calculator and after a short time a green LED on the hub will light up. Then everything is ok. You are ready to start.



Figure 2: Both devices ready for use

## You get to know the light sensor in the Innovator Hub:

As the name suggests, this sensor reacts when light hits it by outputting numbers between 0 and 100 if programmed accordingly. You can see it next to the DATA socket. It is labeled BRIGHTNESS. In order to get the information of the light sensor for the respective lamp, the Innovator Hub has to be sent a small program.

## You program the Innovator Hub to query the light sensor:



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lichtsensor1 4/7
Define lichtsensor1()=
Prgm
Local licht
licht:=2
While licht>1
Send "READ BRIGHTNESS "
Get licht
DispAt 1,"Sensorwert=",licht
EndWhile
EndPrgm
  
```

Figure 3: Program code



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lichtsensor1()
Sensorwert= 0.634804
Fertig
  
```

Figure 4: Program Call with Output

Create the program as shown. When everything is saved, the program can be started with the call "lichtsensor1()". You can easily exit the program by covering the light sensor with one finger. Position the light sensor in front of the different light sources. Try different distances. You may have noticed that the light sensor receives less and less light as the distance increases. An important conclusion is the correct positioning of a work lamp at the workplace. Also the different lights give different sensor values.

The source code explained:

The source code for using the light sensor is stored in a file "lichtsensor1" in the computer.

The source code starts with the line Define light sensor1()=. Within Prgm ... EndPrgm the instructions of the program follow. A local variable is declared. A so called While loop queries the light sensor with Send "READ BRIGHTNESS" until the delivered sensor value is greater than two. With "Get licht" the variable "licht" always gets the most current sensor value. The instruction "DispAt1, "Sensorvalue"=,licht" gives the screen output of the current sensor value.

To end the program, hold the light sensor closed with one finger, then the loop in the program is properly terminated and the program is closed. The finished program is in the online folder and can be saved on the computer. The sensor delivers values between 0 and 100.

### You examine the sensor value at different beam angles of a light source/LED

Make sure that the light source is at a constant distance from the sensor.

The yellow circle on the triangle marks the constant distance to the light sensor.

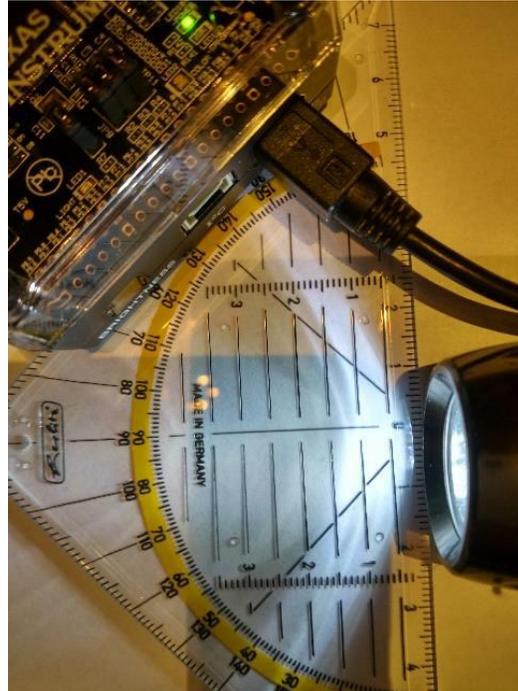


Figure 1: Experimental setup

Note in a table the angle and rounded sensor value for several positions, repeat the experiment with other light sources and draw conclusions from your investigations for the use of the different light sources.

Winkel in Grad	Sensorwert Lichtquelle 1	Sensorwert Lichtquelle 2
0		
20		
30		
40		
50		

Table 1

Conclusion from the investigations:

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**You explore the light at your workplace:**

Use the light sensor to determine the sensor values generated by the ambient light at your workplace at different times of day and note the rounded values in a table.

Uhrzeit	Sensorwert

*Table 2*

Conclusion from the investigations:

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**You explore the importance of the distance of the light source/LED lamp to illuminate the workspace**

Examine the light of a light source/LED lamp with the light sensor for different distances. The ambient light should not change.

Abstand Sensor-Lichtquelle	Sensorwert

*Table 3*

Conclusion from the investigations:

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### The light sensor as luxmeter

The illuminance is given in lux. Guidance on lighting in the workplace can be found in [European Regulations](#). The table 5 gives some guide values for light values in different places.

Parking lot	Living space	General lighting	Concentrated work
10-25 Lux	50-200 Lux	200-300 Lux	500-1000 Lux
Summer day	Misty autumn day	Office work	Workshop work
100 000 Lux	600 Lux	500 Lux	1500 Lux

*Table 4: Illuminance levels*

Use the supplied program in the file Lux Calibration for BRIGHTNESS sensor and use your test setup consisting of computer and Innovator as a luxmeter. Determine the illuminance at the workplace and draw personal conclusions from the measurement with regard to the information given in the table.

Answer:

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### Illuminance is not everything: Lumen

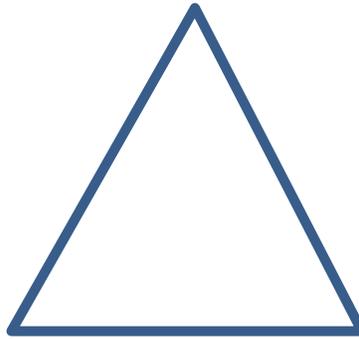
You have already noticed it yourself, with increasing distance from the light source the light intensity decreases because the lamp illuminates a larger and larger area. For this reason there is a further specification for each LED from the manufacturer. The radiated luminous flux is indicated in lumen. The following example illustrates this:

manufacturer's specifications: Luminous flux: 400 lumen, beam angle: 110°.

At a distance of one meter, a luminous intensity of about 150 lux results on an area of about 6.4m<sup>2</sup>. This lamp would not be suitable for the illumination of an office workstation (500 lux see table 5).

**You explore the meaning of the angle of radiation of an LED lamp**

Each LED lamp has a beam angle. (see drawing) Two LED lamps with 30 and 50 degree beam angle are available to illuminate the 1.20 m width shown in the sketch. The respective lamp has a distance of 1.40 m to the width of a surface to be illuminated. Decide by calculation which of the two lamps should be used to illuminate the entire width of the surface. Justify the decision made.



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**You consider another parameter of an LED, the power**

The power of an LED is always specified by the manufacturer in the lamp documentation. The power rating can be used to determine the cost of electrical energy. Different manufacturers offer lamps with the same beam angle and the same light output. However, the manufacturers differ in the indication of the power of the respective lamp. One LED is offered with a power of two watts and the second one with a power of three watts. Compare the two offers under consideration of financial and environmental aspects.

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### 3. Further project ideas

The appendix contains a lot of information about the LEDs, the environmental impact and health risks. These facts and circumstances allow further considerations on the use of LEDs. Your teacher can use the material in other small projects to link the subjects together and address them