Teachers Teaching with Technology™

T³ EUROPE

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The Right Lighting is Important ...

The right lighting in the workplace

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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 light propagation of a lamp/LED. The necessity of using 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.

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:

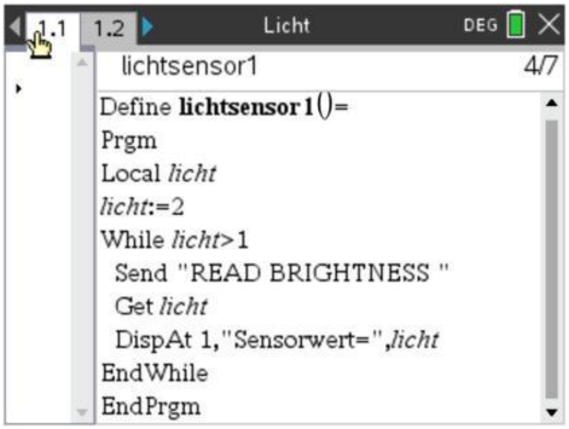


Figure 3: Program code

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 While loop queries the light sensor with Send "READ BRIGHTNESS" while the returned sensor value is greater than two. With "Get licht" the variable "licht" always takes the current sensor value. The instruction "DispAt1, "Sensorwert"=,licht" sends the current sensor value to the screen.

To end the program, cover the light sensor with one finger, then the loop in the program is 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.

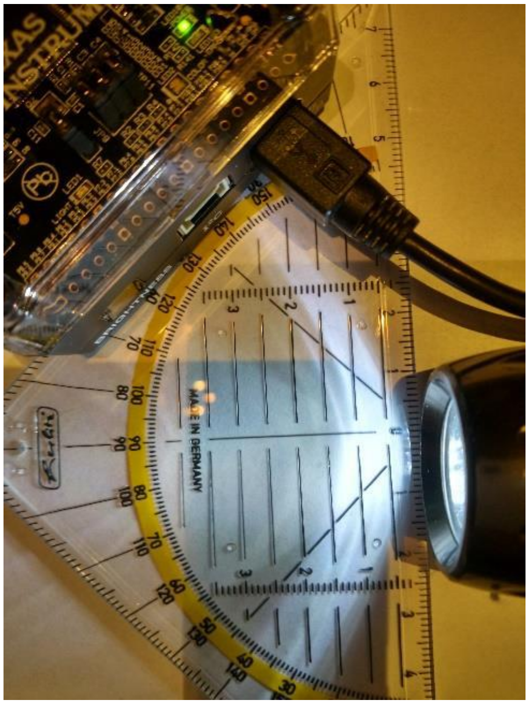


Figure 1: Experimental setup

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.

Angle in degrees	Sensor value light source 1	Sensor value light source 2
0	*72*	*45*
20	*71*	*44*
30	*71*	*40*
40	*65*	*36*
50	*60*	*32*

Table 1

Conclusion from the investigations:

As expected, different light sources provide different sensor values. The light output is not constant at different beam angles. This variation in radiation with angle of LED's should be considered accordingly when using and purchasing LEDs.

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.

Time	Sensor value
8:00	*2*
11:00	*45*
12:00	*60*
16:00	*32*
17:00	*28*

Table 2

Conclusion from the investigations:

The ambient light is subject to variation. At noon the ambient light reached its maximum. Additional lighting is necessary in the morning and evening hours.

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.

Distance from light source	Sensor value
0,1 m	65
0,3 m	8
0,5 m	4
0,6 m	3
0,7 m	2

Table 3

Conclusion from the investigations:

The distance to the light source has a decisive influence on the light yield that occurs at the required location. When installing and selecting lamps, this parameter is crucial for the correct illumination of the desired place. A too low light intensity can have a negative effect on the health of the persons concerned.

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 5: 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.

Conclusion from the investigations:

Measured at the workplace with LED switched on: 1200 Lux. Concentrated work is possible with the lighting at the workplace. Possibly an LED with less lux should be used. This leads to a lower impact on the environment.

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 falls on an area of about 6.4 m^2. This lamp would not be suitable for the illumination of an office workstation (500 lux is needed, see table 5).

There is a lux/lumen calculator to be found at https://www.airfal.com/fr/eclairage-technique-actualites/calculateur-de-lumens-lumen-a-lux-a-candela-15792/.

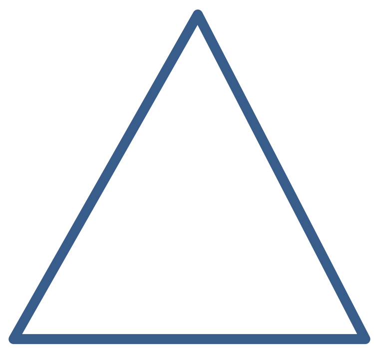
The **lumen is a unit of measurement of the luminous flux** (symbol *lm*). *Luminous flux is a measure of the total amount of visible radiation emitted per second by a bulb or lamp. Thus, " a lumen is the luminous flux captured by a surface of 1 square meter located at 1 meter from a light source having a light intensity of one candela.*

The **lux is a unit of measurement for illuminance** (symbol *lx*). *It characterizes the luminous flux received per unit area: " a lux is the illumination of a surface which receives, in a uniformly distributed manner, a luminous flux of one lumen per square meter* .

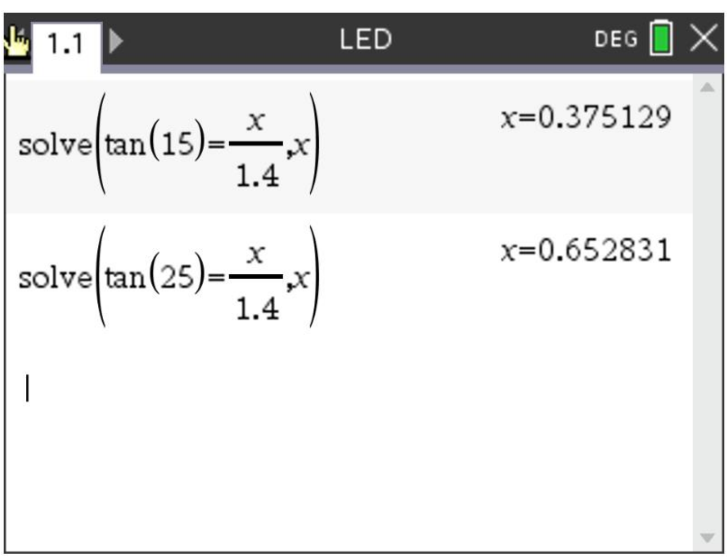
1 lux = 1 lumen / m ^{2}

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

Each LED lamp has a beam angle. (see drawing) Two LED lamps with 30 and 50 degree beam angles 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.



Conclusion from the investigations:



Only the lamp with a beam angle of 25 degrees is suitable for these requirements.

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.

Conclusion from the investigations:

From the point of view of an energy-saving use of lamps, the lamp with the lower output should be preferred.

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 in a cross-curricular way.