ScienceCube

C23C
Light
User Guide

June 28 2010, Second Edition

WARNING:

For safety reasons and to avoid personal injury, read all operating guides and information in the product guide. Please check that this product is operating properly prior to when you intend to use it for educational purposes only. Use this device and sensors for teaching and learning. The information given in this electronic document shall not be regarded as a guarantee or warranty of physical characteristics and any conditions. We will not replace or cover the costs of a damaged sensor or probe due to negligent or destructive, improper use.

1. DO NOT attempt to modify Mentor device and sensors in any way. This may result in fire, injury, electric shock or severe damage to you or them.
2. DO NOT operate Mentor device and sensors with wet hands, this may cause an electric shock.
3. DO NOT use Mentor device and sensors in close proximity to flammable or explosive gases, or chemical vapors. Use this product in a well ventilated area.
4. Optical radiation hazards which can be produced by any artificial sources, the sun light source or others as well as continuous or repetitive exposure to them may cause greater injury or damage such as blindness, skin cancer, and temporary or permanent loss of vision.
5. For safety reasons keep this sensor out of reach of children or animals to prevent accidents, for example swallowing small size of the sensor. DO NOT allow children to play on or around the sensor.

CAUTION:

1. DO NOT use Mentor device and sensors in extreme conditions which are over the operating range and short-term exposure limit conditions. Stresses above input range may cause permanent damage.
2. Exposure to absolute maximum conditions for extended periods may degrade sensor reliability.
3. The sensors are permanently sealed during construction and cannot be opened to any purpose. DO NOT attempt to decompose, modify or repair the sensor in any other ways. This may cause permanent damage to the sensor.

Features and Specifications

Features

Item	Description
Feature	Surface mount photoelectric cell to measure the brightness. Optical glass window as a protective element. Standard tripod mount thread (1/4-20). Protective cover to avoid scratching the window.
Dimension	Sensor base housing: 32x18x64 (WxDxH) in mm Optical glass window: 24x30 in mm
Usage	Use only in a dry place at room temperature below +40°C.

Specifications

Item	Description
Input range	Default : 1 to 65535lux Adjusted[1]: 0.35 to 22937lux or 1.53 to 100487lux
Resolution	Default 65535lux: 1lux Adjusted: 0.35lux (22937lux), 1.53 (100487lux)
Sensitivity	Sensitivity variation[2]: <38% Measurement deviation from linear correlation: <5% (200lux to 65535lux)
Sampling rate	Default sampling periods: 0.2sec (5samples/sec) Max[3]. 100samples/sec in low resolution mode
Reading time	120ms in 1 to 65535lux 286ms in 0.35 to 22937lux

[1] The sensor allows an adjustment of the transmission rate (reaction time of the sensor) to detect minimum 0.35lux, maximum 100000lux using this function.

[2] Due to the manufacturing process of the sensing element (photo detector), there is a sensitivity variation which yields different output value in detected illuminance. This sensor offers a sensitivity binning function to account for sensitivity variation.

[3] Maximum sampling rate is specified with the Light application software for Mentor.

Item	Description
	65ms in 1.53 to 100487lux
Peak wave length	560nm
Light source dependency	Output ratio between incandescent and fluorescent light : 1.0 at EV=1000lux

Additional equipment or application

Mentor device and MentorStart application software needed. If you are using Mentor application, consult your instructor for more information.

CAUTION:

1. DO NOT use this sensor in close proximity to flammable or explosive gases. Chemical vapors may interfere with the polymer layers used for capacitive this sensor and high levels of pollutants may cause permanent damage to this sensor.
2. DO NOT use or expose this sensor at the maximum range under 1minute residence time (exposure limit with max. input range)
3. Prolonged direct exposure to extreme conditions may cause significant property damage. Care must be taken not to expose this sensor to direct sunlight.
4. DO NOT place sensor or cable in water, liquids, flame or on a hot plate.

Setup and Usage

1. Launch the MentorStart software and connect the sensor to the sensor port in your Mentor device. MentorStart will automatically detect the sensor. Place the sensor in a dry place.
2. Measure the brightness[4] with distance or the illuminance on a surface in lux with reflected or incident light sources such as incandescent lamp, fluorescent lamp, halogen lamp, white LED or every day light sources.

[4] The illuminance is the mathematical term for the brightness and the light sensor is photo detector which is designed to perceive brightness in the same way as human eyes do.

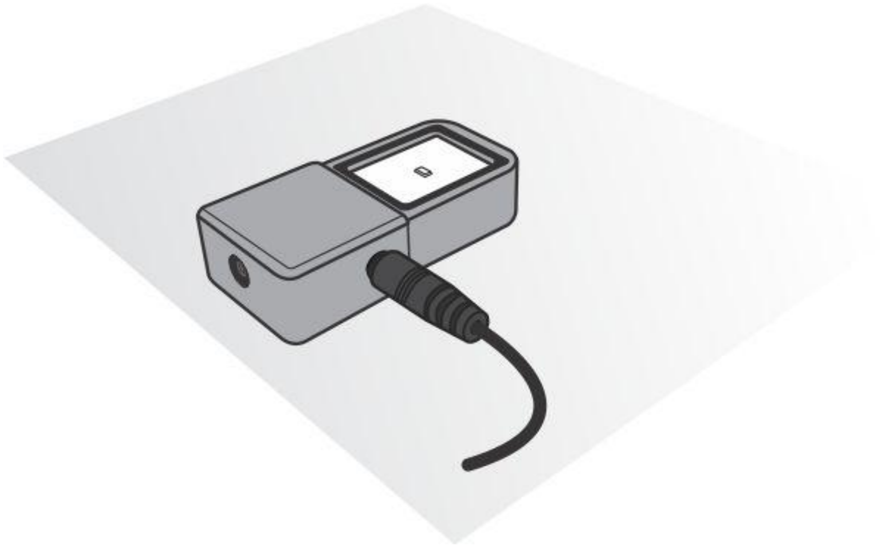

Fig.1 Measure the illuminance of an incident light on the table. You can consider the total amount of light described numerically with the brightness which is a part of an everyday experience including any reflective or ambient shadows to surfaces near the light such as people, computers or books.

Fig.2 Reading the illuminance in lux. While you are reading the illuminance in lux, you can take the values which will vary depending on the direction of the light source and the lighting environment.

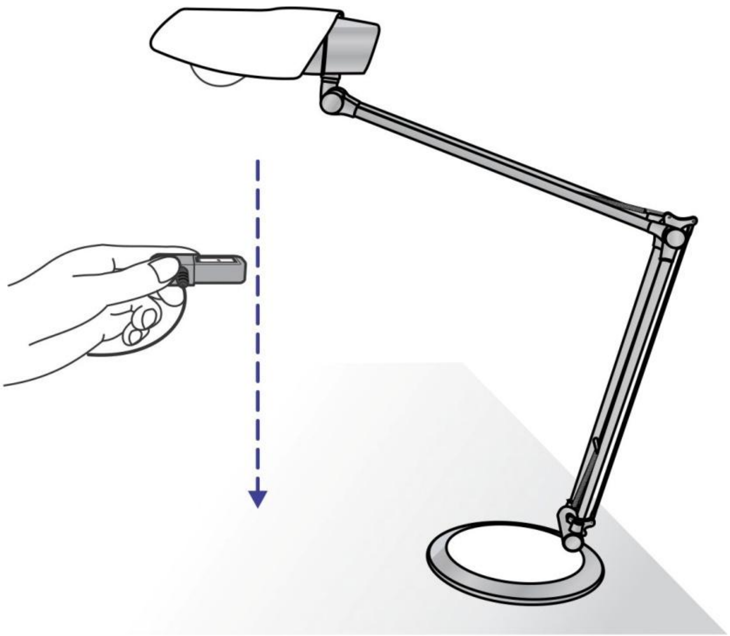

Fig.3 Explore the relationship between distance and brightness or the intensity of light for a light bulb while you measure the distance to light. Student can easily make this measurement as the followings: hold the sensor and move it downward along an imaginary vertical line between the light and the table top, and measure the vertical distance from the lamp while you can read the value of the illuminance.

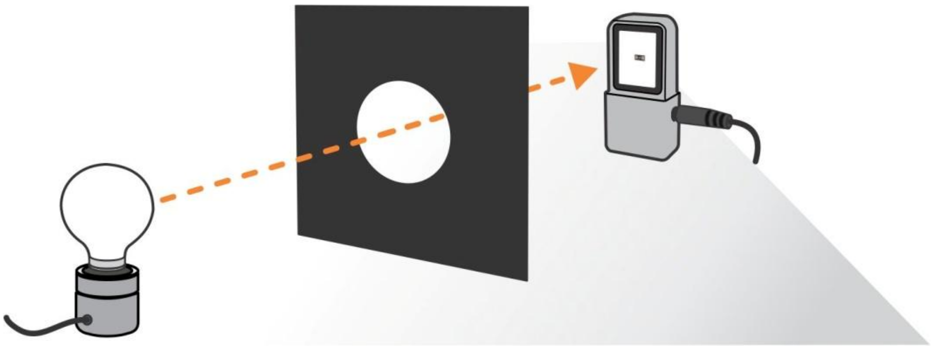

Fig.4 Measure the brightness with a baffled light track. Move the baffle between the light bulb and the sensor, or use another baffle which has a different diameter of the hole, and then discuss how a baffle reduce the influence of light reflections.

Guide to Physics Experiments

Table.1 Physics experiments using the Light sensor with everyday materials.

Students' activity (Science Experiments)
Measure the intensity of light in mathematical terms.
Test the inverse-square law in the laboratory
Measure the illuminance for recommended lighting environment

NOTE: The illuminance is measured in lux and means the luminous intensity or power factored by the eye's sensitivity per unit area on an illuminated surface,

Illuminance E =Intensity I / (distance r)^2

in according to the general inverse square law where I is the luminous intensity of the light by an isotropic (point) source. Students can measure the quantity in mathematical terms (lux) which is most commonly used to state the recommended requirements for architectural lighting, or the amounts of lighting environment such as such as incandescent lamp, fluorescent lamp, halogen lamp, LED or everyday light sources for example, streetlight, office desk lighting, overcast sunny day, sunlight (not direct sun), sunrise or sunset on a clear day, recommended lighting for reading and family living room.

Test Inverse-Square law: Light at a distance

In this activity students can explore the inverse square law which defines the relationship between the brightness from a point source and distance. You can test how the brightness depends on only the intensity of the light and the distance. As shown in the diagram below, you can record the brightness at any distance which is measured to the first illuminating surface, for example, the glass envelope of frosted light bulb, the filament of a clear bulb, or the envelope of LED light bulb.

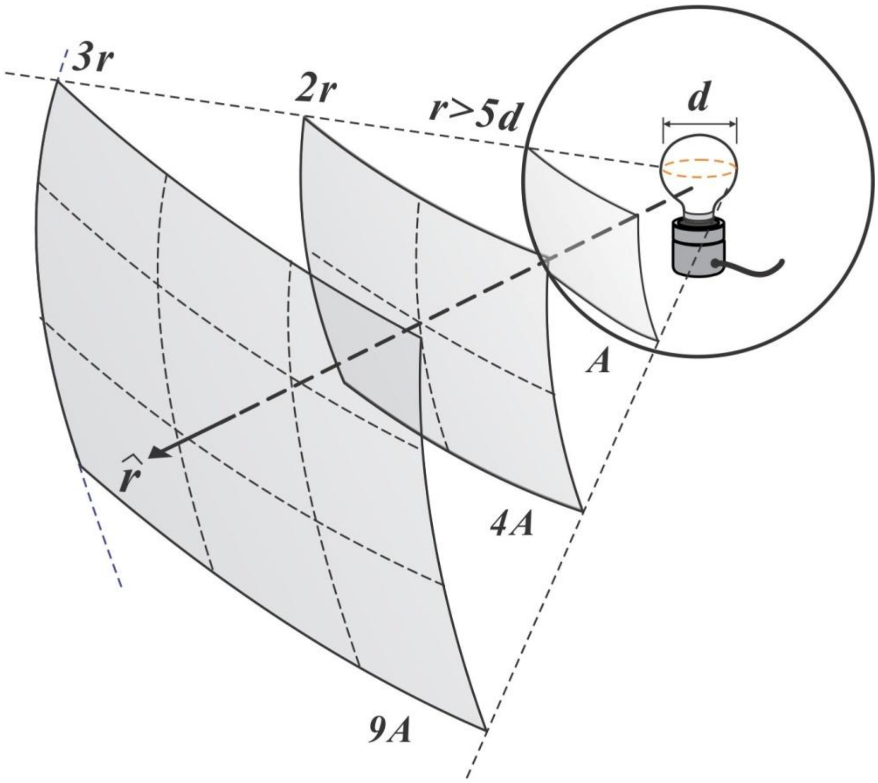

Fig.1 This diagram shows inverse square law of light. If you have determined the brightness per unit area A, it will be proportional to the inverse square as much at distance.

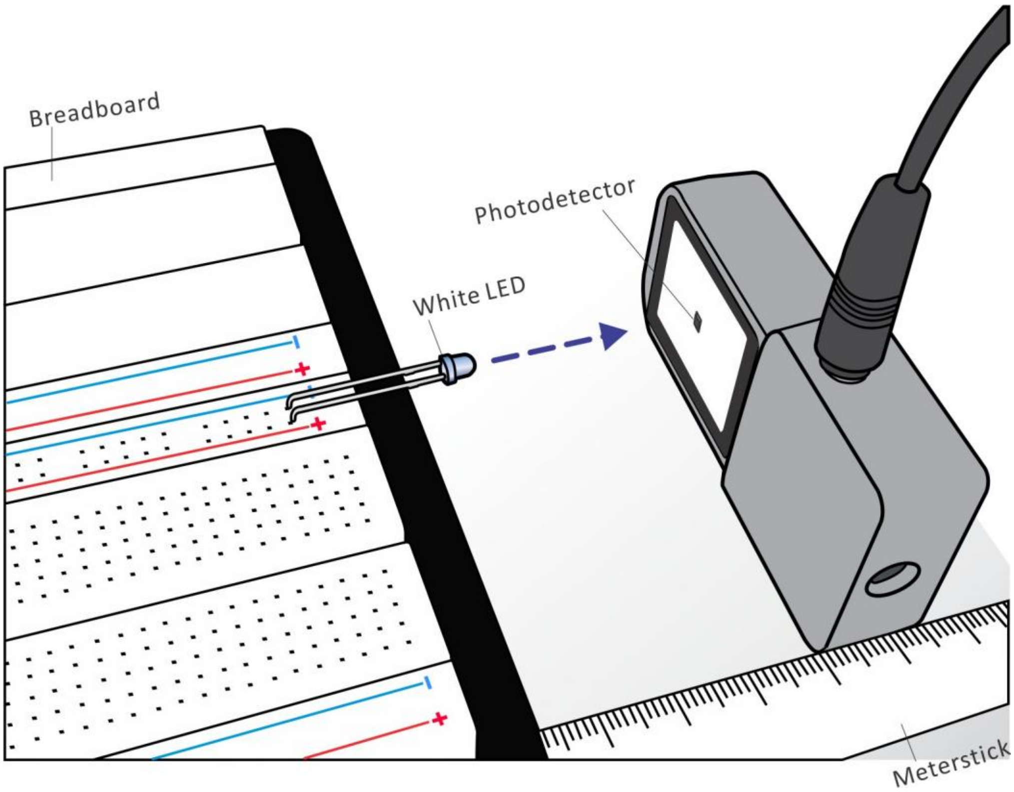

Fig.2 Students can easily demonstrate the inverse square model experiment with white LED as the point source.

NOTE: The inverse square law can only be modeled mathematically in cases where the light source approximates a point source of light as seen by the sensor. The distance to a frosted light bulb should be greater than 5 times of the diameter of the bulb for the approximation as a point source[5].

If you are using Microsoft Excel, you can solve the mathematical model[6] from which you analyze the data. When you construct a model of the data you can solve it using Excel Solver as the followings.

	A	B	C	D	E	F	G
1	d (m)	D= (d^-2)	E (Lab)	E (Model)	(Lab-Model)^2		
2	0.035	816.3	65	=$G$4/(A2^2)+$G$5	=POWER(C2-D2,2)	White LED Vcc (V)	3.0
3	0.055	330.6	29			Target	=SUM(E2:E11)
4	0.075	177.8	16			Slope	
5	0.095	110.8	11			Intercept	
6	0.115	75.6	8				
7	0.135	54.9	6				

The figure Fig.3 shown below is a calculating the relationship of the inverse square model. The mathematical equation of this activity is,

E= A/ (d^2) + B, or E=(Slope)*D+(Intercept) ...Inverse Square Model
E=A*(d^B) ...Power Model

and when you are setting Intercept to zero, you have the inverse square model. Especially If you use the general power model of **E=A*(d^B)**, you can test how it may provide a better than the inverse square model. You can also discuss if there are error propagation such as an uncertainty of distance measurement from the light source to the sensor, ambient light in the room or unsuitable lamp which is not the point source.

[5] Based on the "five times rule", a light source begins to behave as a true point source at a distance greater than five times the largest dimension of the light source. Alexander D.Ryer, The Light Measurement Handbook (ISBN 0-9658356-9-3), p.26.

[6] See Hyunsoo Kim, Computational Dynamics with curriculum guide, 2008.

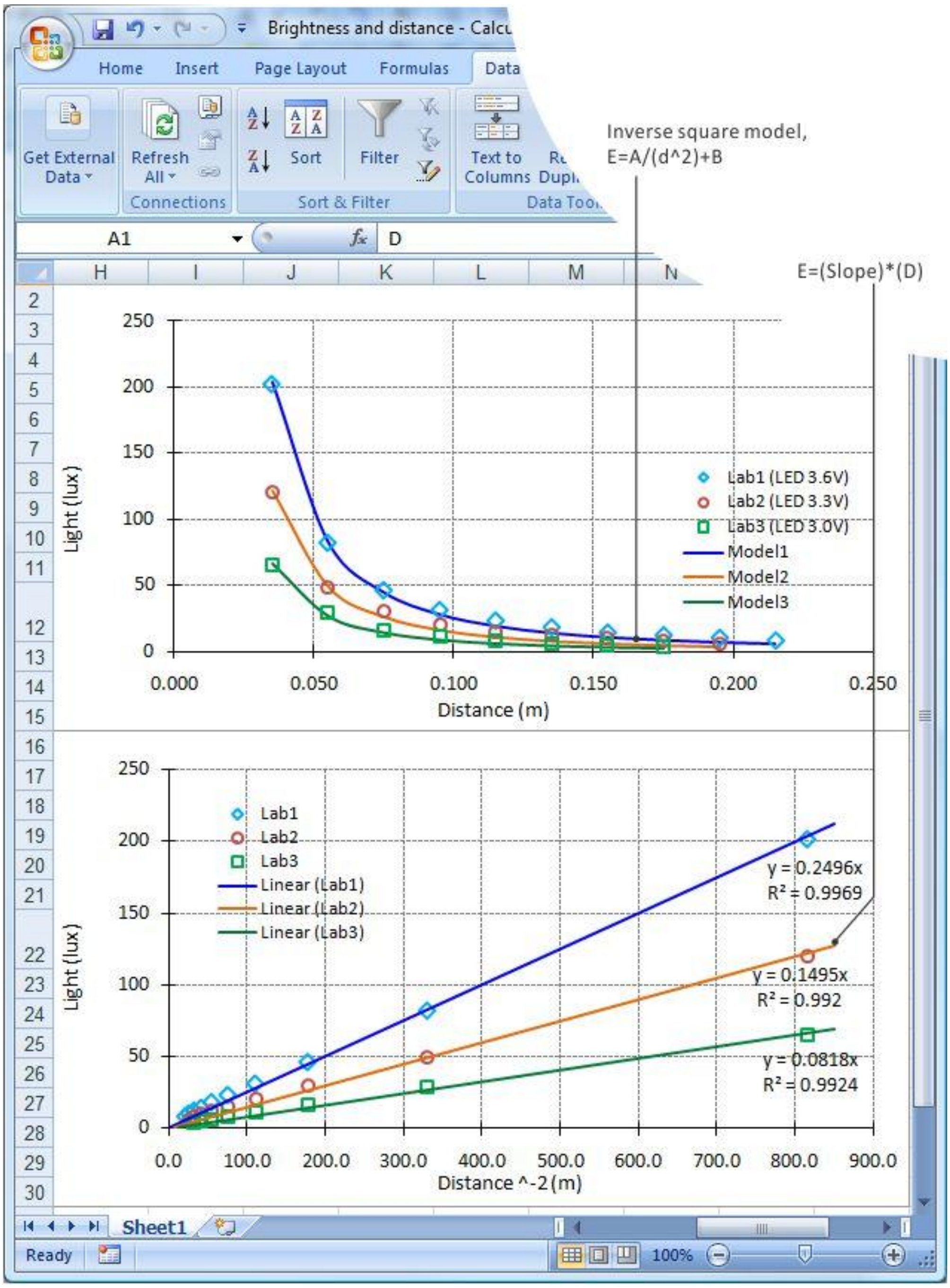

Fig.3 Calculating the slope and R-squared of the model. The graph of the brightness of LED light versus distance shows how the model does well fit the data. You can explore how a brighter LED light affect the parameters Slope and Intercept in the model. For example, as the provided support voltage of the LED (Vcc) is 3.0V, 3.3V and 3.6V, you can calculated the slope depend on the model you use.

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For more information about installing Mentor, using other applications and getting the feedbacks, contact: ScienceCube international distributor.

If you have any questions about a guide to physics experiment using the sensor, please contact author at sooall@snu.kr