ScienceCube

The brightness of stars according to distance..

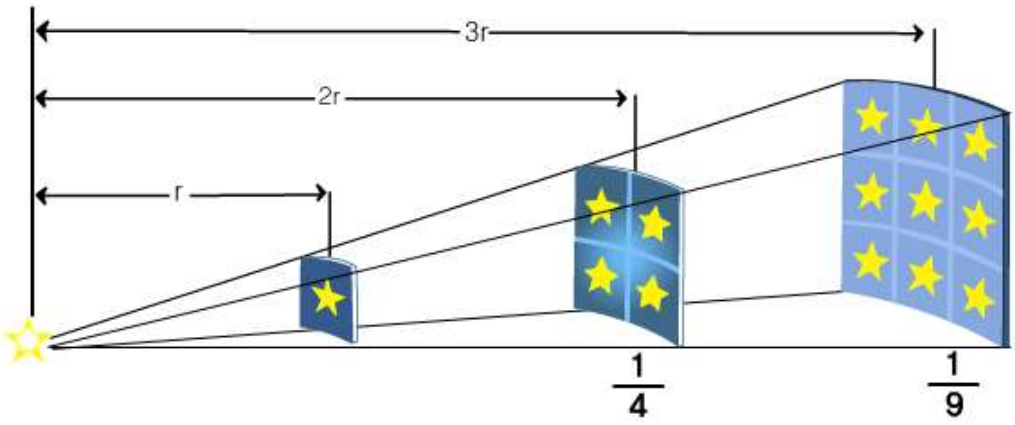
As we move away from a light source, we can measure how the brightness of the light changes and explain the relationship between distance and the intensity of the light.

Fundamental Concept

1. **Brightness of Stars**

   The factors that determine the brightness of a star are its intrinsic luminosity and the distance to the star.

2. **Brightness of Stars and Distance**



Even the same star appears dimmer when it is farther away and brighter when it is closer.

$$\text{Brightness of Stars} \propto \frac{1}{(\text{거리})^2}$$

Distance

3. Brightness and Magnitude of Stars

① The brightness difference between stars of 1 magnitude is about 2.5 times.

② A 1st magnitude star is about 100 times brighter than a 6th magnitude star.

4. Apparent Magnitude and Absolute Magnitude of Stars

1) Apparent Magnitude and Absolute Magnitude

Division	Apparent Magnitude (Visual Magnitude)	Absolute Magnitude
Feature	✓ The brightness of the star as seen with the naked eye ✓ The smaller the apparent magnitude, the brighter it appears to us	✓ The brightness of the star if it were placed at a distance of 10 parsecs from Earth ✓ The smaller the absolute magnitude, the more energy the star actually emits

2) Distance to the Star

The larger the value of (apparent magnitude - absolute magnitude), the farther away the star is.

Stars closer than 10 parsecs	Apparent Magnitude < Absolute Magnitude
Stars at 10 parsecs	Apparent Magnitude = Absolute Magnitude
Stars farther than 10 parsecs	Apparent Magnitude > Absolute Magnitude

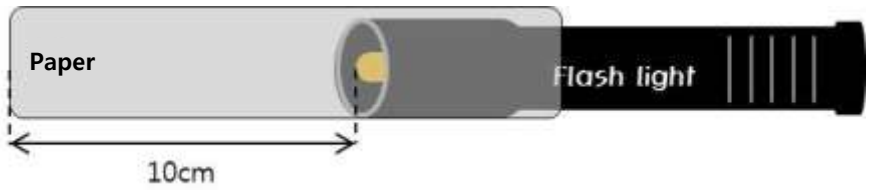
Experiment

Materials Needed

Interface, Science# program, light sensor, flashlight, 30cm ruler, white paper, height-adjustable props, cellophane tape, double-sided tape

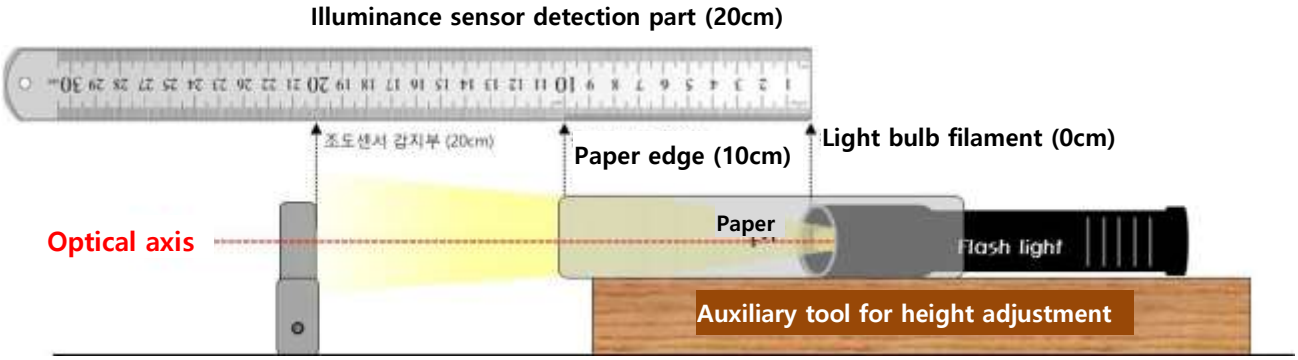
Experiment Setup

1. Place the flashlight on the white paper, ensuring the filament is positioned 10cm from the edge. Wrap the paper around the flashlight and secure it.



2. Fix the 10cm ruler to the floor with cellophane tape, aligning the light sensor 20cm away from the filament. Secure the light sensor to the floor with double-sided tape.

3. Ensure the flashlight is horizontal on the desk, aligning the light sensor's light detector and the flashlight's filament on the same optical axis by adjusting the height..

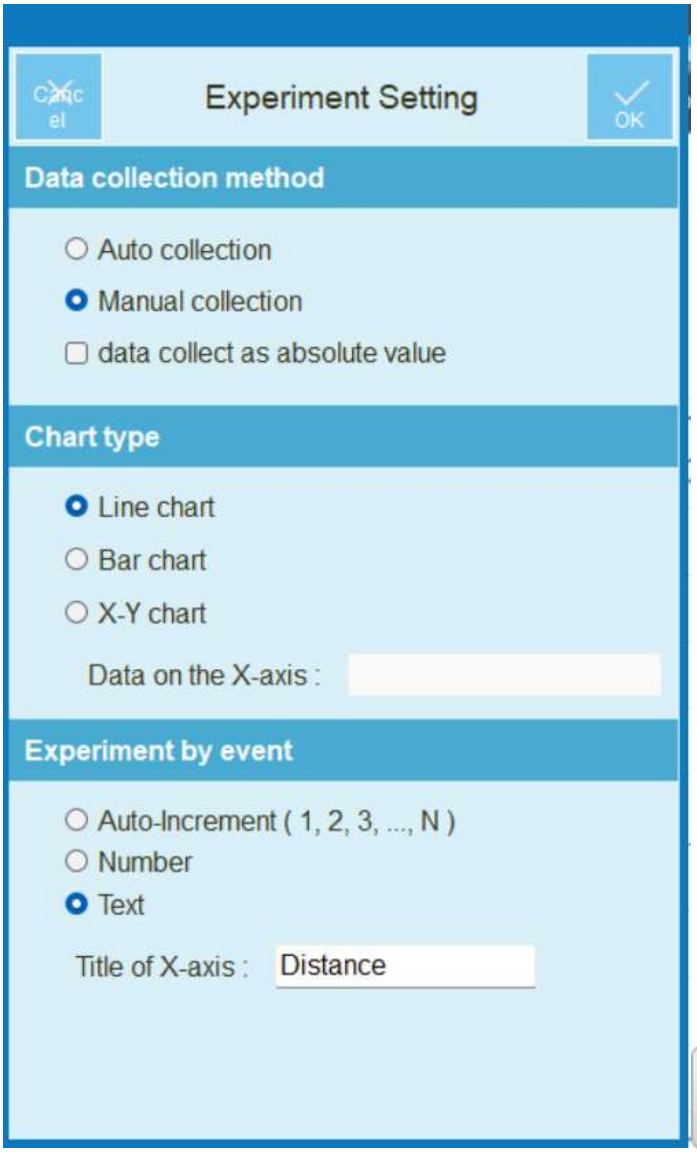


Interface Settings

1.  Run Science#..

2. Connect the interface and the light sensor.

3. Press  the appropriate button to either manually set up the experiment environment or use the auto-setup  feature.




[auto-setup]

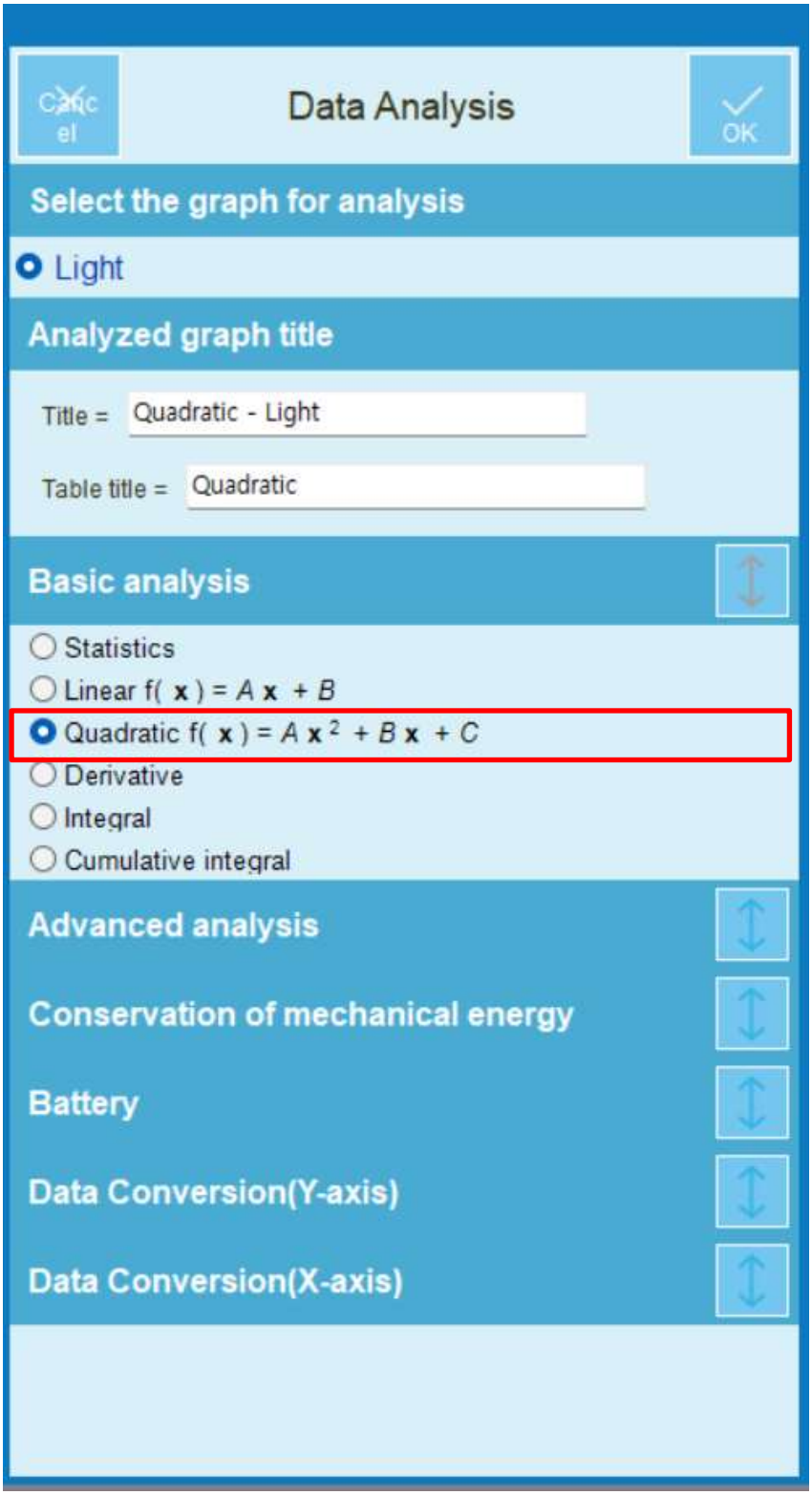
Data Collection

1. Press the start button  , turn on the flashlight  , and measure the illuminance at a distance of 20cm.

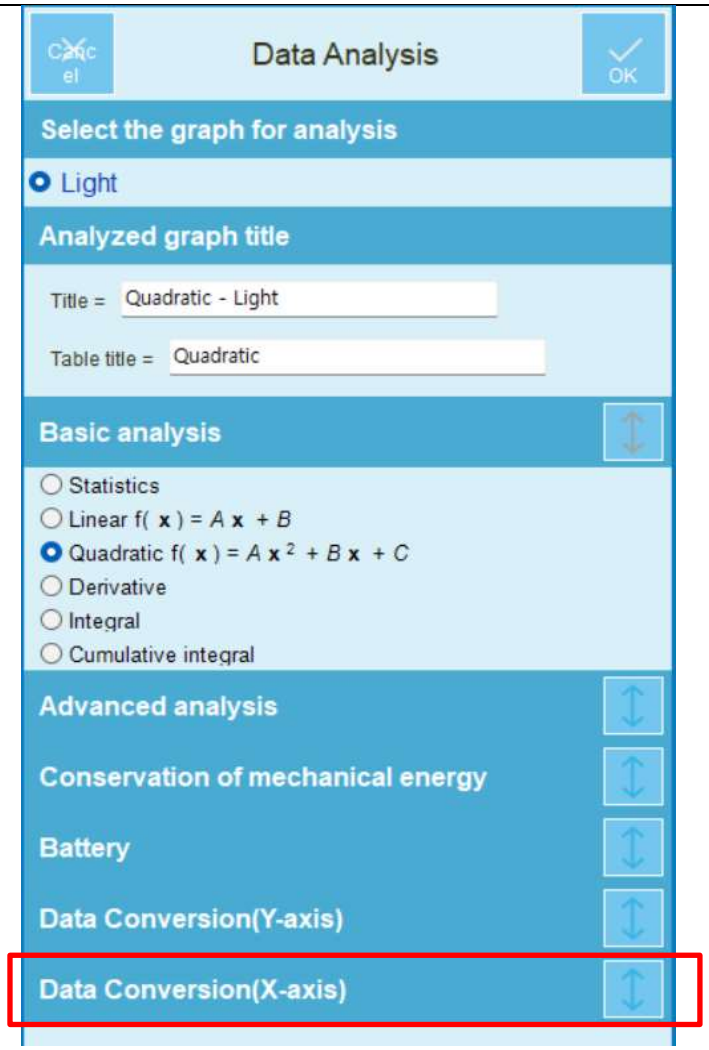
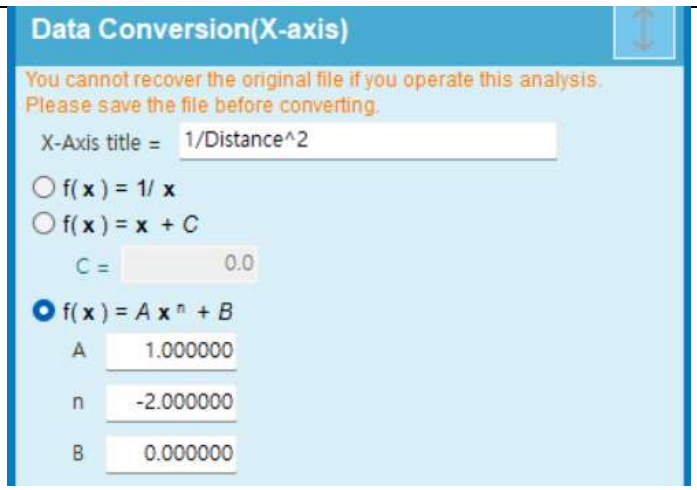
2. Gradually move the light sensor away from the filament in 1cm increments, measuring the illuminance at each distance.

3. After measuring the illuminance at a distance of 30cm, press the stop button  to complete data collection.

4. Create an [Illuminance-Distance] graph by following the specified steps  .


Cancel
Data Analysis
OK
Select the graph for analysis
Light
Analyzed graph title
Title = Quadratic - Light
Table title = Quadratic
Basic analysis
Statistics
Linear f(x) = A x + B
Quadratic f(x) = A x 2 + B x + C
Derivative
Integral
Cumulative integral
Advanced analysis
Conservation of mechanical energy
Battery
Data Conversion(Y-axis)
Data Conversion(X-axis)

5. Press the button  and complete the [Illuminance-(1/Distance^2)] graph as follows..

1. Set the X-axis	
2.Enter the function	

✓ The closer the [Illuminance-(1/Distance^2)] graph is to a straight line passing through the origin, the more approximate it is to the theoretical value..

Data Analysis

Record Data

1. Plot the brightness of the light at each measured distance on a graph.

2. Record the brightness at each measured distance in the table below.

Distance (cm)	Brightness (Lux)
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	

3. Represent the relationship between [1/Distance^2] and illuminance on a graph.

4. Among the following formulas, find the one that establishes the relationship between distance and light brightness, and explain the relationship between distance and light brightness..

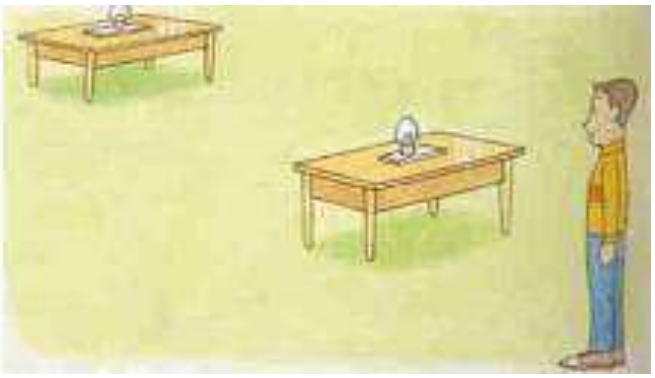
<Directly proportional> $I = K \cdot d$

<Inversely proportional> $I = K \cdot \frac{1}{d}$

<Inversely proportional to the square> $I = K \cdot \frac{1}{d^2}$

Data Application and Extension Activities

1. Observe and describe the brightness of two 30W bulbs placed at different distances..



2. Complete the following sentences correctly.

1) If a star's distance increases by a factor of 4, its brightness (increases, decreases) to ($\frac{1}{4}$, $\frac{1}{16}$)

2) If a star's distance decreases to $\frac{1}{10}$, its brightness (increases, decreases) by (10, 100) times.

3. The following table shows the brightness differences for various magnitude differences:

Magnitude Difference	1	2	3	4	5
Brightness Difference (Times)	2.5	6.3	16	40	100

1) The apparent magnitude of Rigel in Orion is 0.1, and the apparent magnitude of Polaris is 2.1. Which of the following correctly compares the brightness of these two stars?

① Rigel appears about twice as bright as Polaris.

② Polaris appears about twice as bright as Rigel.

③ Rigel appears about 6.3 times as bright as Polaris

④ Polaris appears about 6.3 times as bright as Rigel

⑤ Rigel appears about 16 times as bright as Polaris

2) If a 2nd magnitude star moves to a distance four times farther away, what will its apparent magnitude be?

4. We have confirmed through experiments that the brightness of a star changes with distance. What conditions should we consider when comparing the actual brightness of stars?

5. List the reasons why the brightness of stars differs.

6. List various methods for measuring the brightness of stars.