Candidate 4 evidence

The inverse Square Law of Irradiance

Aim: To determine the relationship between the distance from a point source and the irradiance at that point.

Underlying Physics:

The inverse square law is a principle which states that light propagates ~~in space~~ evenly in space.

A point source is used when investigating the inverse square law of irradiance as it has no limit to its range. The smaller a source of light is, the more it behaves like a point source. An example of a point source would be a star. A point source emits light equally in all directions.
The inverse ~~is~~ square law of irradiance states that as the distance from a point source increases, its irradiance decreases. This is because there is a lesser number of photons hitting the same point each second.

There are several equations linking irradiance and distance:

$I = \frac{k}{d^2}$ $\quad I \propto \frac{1}{d^2}$ $\quad I_1 d_1^2 = I_2 d_2^2$

$I = \frac{P}{A}$

Irradiance is known as the power per metre squared. It is measured in (wm^{-2}). The area can be calulated using $4\pi r^2$ (m^2). This proves $I = \frac{P}{A}$ *

Irradiance is inversley proportional to distance square. As Irradiance multiplied by distance squared equals a constant, we can prove that $I_1 d_1^2 = I_2 d_2^2$, aswell as $I = \frac{k}{d^2}$.

Where : I - irradiance (wm^{-2})
d - distance (m^2)
k - Constant

* Where I = irradiance (wm^{-2})
P = Power (W)
A = Area (m^2)

Experimental Method:

A bulb was connected to a power supply and placed ~~the was~~ opposite ~~across~~ from a light sensor.* The light sensor was connected to the Alba Software on the computer. The ~~voltage of the bulb was recorded by~~ bulb was then switched on. The Alba Software recorded the irradiance from the bulb. A background reading of irradiance was recorded first to correct the results.

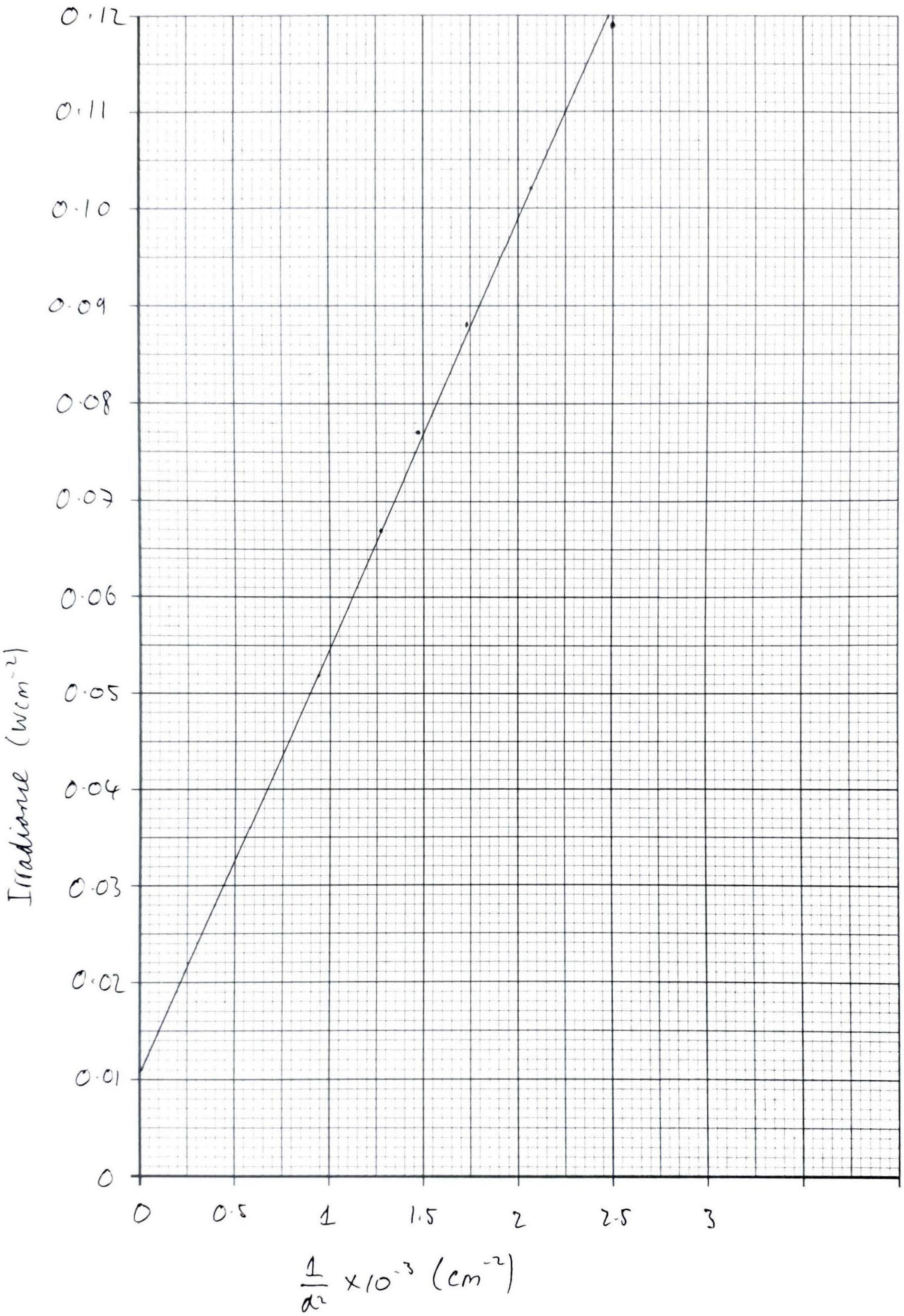
* The distance was measured using a ruler.

Distance between bulb and light sensor (cm)	$\frac{1}{d^2}$ (cm^{-2})	Irradiance ($W cm^{-2}$) 1	2	3	4	mean
20	2.5×10^{-3}	0.120	0.124	0.114	0.119	0.119
22	2.07×10^{-3}	0.101	0.103	0.101	0.102	0.102
24	1.74×10^{-3}	0.091	0.090	0.086	0.085	0.088
26	1.48×10^{-3}	0.079	0.076	0.075	0.077	0.077
28	1.28×10^{-3}	0.068	0.067	0.065	0.068	0.067

$$\frac{1}{d^2} = \frac{1}{20^2} = \underline{\underline{2.5\times10^{-3}}}$$

$$\text{mean} = \frac{0.068+0.067+0.065+0.068}{4} = 0.067$$

Graph of my results



Uncertainties:

Scale Reading uncertainties

The Scale reading uncertainty for the ruler was ± 0.05cm.

The Scale reading uncertainty for the alba Software was ± 0.001 Wcm^{-2}

Random uncertainty.

For 20 cm $\frac{0.124 - 0.114}{4}$
$= \pm 2.5 \times 10^{-3}$ Wcm^{-2}

For 22 cm $\frac{0.103 - 0.101}{4}$
$= \pm 5 \times 10^{-4}$ Wcm^{-2}

For 24 cm $\frac{0.091 - 0.085}{4}$
$= \pm 1.5 \times 10^{-3}$ Wcm^{-2}

For 26 cm $\frac{0.079 - 0.075}{4}$
$= \pm 1 \times 10^{-3}$ Wcm^{-2}

For 28 cm $\frac{0.068 - 0.065}{4}$
$= \pm 7.5 \times 10^{-4}$ Wcm^{-2}

Analysis:

$$\text{Gradient of graph} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{0.09 - 0.015}{(1.8 \times 10^{-3}) - (0.1 \times 10^{-3})}$$

$$= 44.1176\ldots$$

$$= 44.1$$

Constant = gradient of graph

Constant = 44.1

$$I = \frac{k}{d^2} \qquad I = \frac{44.1}{d^2}$$

$$Id_2 = k$$

20cm - $0.119 \times 20^2 = 47.6$

22cm - $0.102 \times 22^2 = 49.4$

24cm - $0.088 \times 24^2 = 50.7$

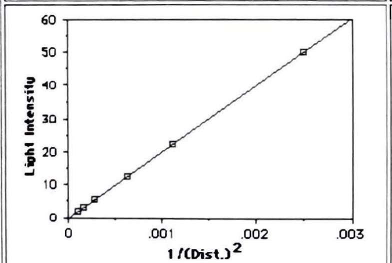
26cm - $0.077 \times 26^2 = 52.1$

28cm $0.067 \times 28^2 = 52.5$

As there were uncertainties in my results, my graph proves that $I = \frac{k}{d^2}$. If the uncertainties were reduced I would have had more accurate values.

The data below was gathered while observing the manner in which light intensity dropped off as the student moved away from a light source. Use one or more of the four methods of analyzing the data to see if you can discover the mathematical relationship. If you think you have the form of the proportion, then go ahead by clicking the method you used to do the analysis.

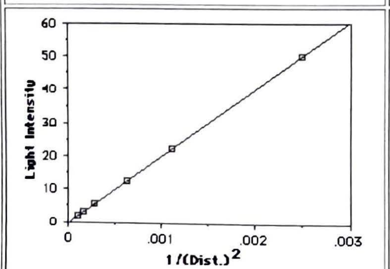
Distance cm	Light Intensity units
20	50
30	22.2
40	12.5
60	5.5
80	3.1
100	2.0



By plotting the reciprocals of the distances squared versus the intensities, we now have a straight line graph. This is a solid indication of the type of proportion that is at work in this lab.

From the graph we can immediately write:

$$I = k\,(1/d^2)$$



The mathematical proportion derived from the straight line states that the intensity (I) is directly proportional to the square of the reciprocals of the distance ($1/d^2$).

A proportion of this type is called an "**Inverse Square**" proportion.

Conclusion:

To conclude, through my experimental results, I calculated that ~~[illegible]~~ $I \propto \frac{1}{d^2}$

Evaluation:

My experimental results were reliable as they followed the same trend as my second data source.

To decrease my random uncertainty I could have had a greater number of repeats for my experiment. This would improve the accuracy of my results.

The best fit line on my graph should have cut through the origin. This didn't happen as the light level in the room changed. To improve my results I could have kept the background light level constant, or taken the background light level before every result, this would allow me to correct my results. Allowing the graph to cut through the origin.

To reduce my scale reading uncertainty I could have used a ruler with a smaller unit of values. This would improve the accuracy of my results.

Citation:
Second experiment reference URL:

http://Cbakken.net/proportions/Unknown.html

Accessed 28/11/2018

Underlying Physics:

Paul Chambers, Iain Moore and Mark Ramsay, Higher Physics for CFE, Hodder Gibson, Paisley, 2013, Pages 151-153.

ISBN 978-1-4441-6857-0

https://www.bbc.com/bitesize/guides/zwwjjxs/revision/1

Accessed 28/11/2018.