Science in your pocket – Teacher Notes

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Figure 1 – iPhone apps sphere

Aim

Revolution in technology is surprising us every day with the myriad of applications and inventions which help us with our daily tasks. Who has ever imagined that we could have carried a compact mobile laboratory in our pocket! This is simply true today at a click of a finger. Our smart phones can do far much than what we can imagine, in addition of being a tool for communication, a camera, a torch, a translator, a GPS, an alarm, a stopwatch, a diary and much more, it can also be used to do very sophisticated measurements. This includes being an oscilloscope, a ruler, a temperature sensor and a light meter. In this experiment, students will use an application on their smart phone to measure the change in intensity of light with change in distance from a light source.

Plan

It is important to ensure students understand the applications of the science they are learning, one of the applications of using light meters is in cinematography and photography to plan the best lighting conditions.

Make sure students have chosen an appropriate and reliable application for measuring the light intensity. In this experiment, students have the freedom to choose their own application so it is a good idea to compare the results obtained from different applications.

They have to try it until they are confident with their measurements before writing their results.

It is very important to discuss with students the risks associated with the experiments, this includes avoiding direct looking at the source of light and making sure they don't drop their devices. They have to report any glass breakage to their teacher once it happens.

Students should form groups of three and assign a role for each member in the team.

Conduct

This experiment is a guided inquiry where students will select their question and make their own predictions. They will be guided during planning, conducting and recording. The teacher can guide them with their analysis, reasoning and making conclusions.

The experiment has two parts, in the first part (part A) they will use the application on their smart phone to measure how intensity of light changes with changing the distance away from the light source and in the second part (part B) they will repeat the experiment using a light meter.

In designing their experiments to make the measurements, students should make sure they only change one variable while keeping all other variables constant. The variable they change in this experiment is the distance, they have to keep the settings on their light meter the same, use the same source of light and keep all conditions the same except the variable they are testing. Ask the students to draw a labelled diagram for their setup. They can start measuring at a distance of 10 cm from the light source and then move the light meter further away with increments of 5 cm.

It is important to repeat the measurements at least three times to enhance the reliability of their results. The unit they measure is called the lux which is equal to lumen per square meter. This is equivalent to the intensity of light as seen by the human eye.

It is best if the same student does the same role in order to reduce the amount of human error associated with the measurements.

Analyse

Students will analyse their data for parts A and B in the same manner. They can tabulate their results using a table similar to the one below.

Light intensity (lux)				**Distance, r (m)**	**$1/r^2$ (m^{-2})**
Reading 1	**Reading 2**	**Reading 3**	**Average**		
				0.10	

To find the average light intensity, simply add readings 1, 2 and 3 and divide the sum by 3.

After finding the values, students are required to deduce the relationship between the light intensity and the distance from the source of light. There are a number of ways to do this.

1. Check the literature to find that intensity is inversely proportional to the distance squared.
2. Look at the values and find that as distance increases, intensity decreases. This means there is an inverse relationship between the 2 values. Trying $\frac{I_1}{I_2} = \frac{r_2}{r_1}$, students will find that it is not true, however the value of $\frac{r_2}{r_1}$ is actually the square root of $\frac{I_1}{I_2}$.
3. Draw a graph on excel similar to figure 2 and add a trendline (a power trendline) and tick the box for displaying equation which will show the relationship.

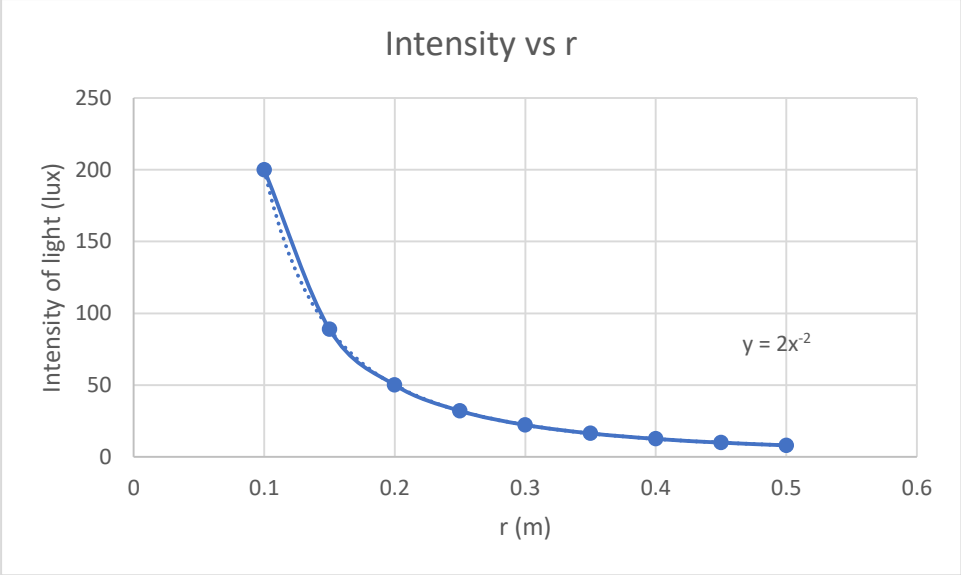

Figure 2- Intensity of light vs distance from the source

The next step is to plot intensity of light vs $1/r^2$, if the graph shows a straight line, this means that their results agree with the fact that intensity of light is inversely proportional to the square of the distance away from the light source. They should get a graph similar to figure 3.

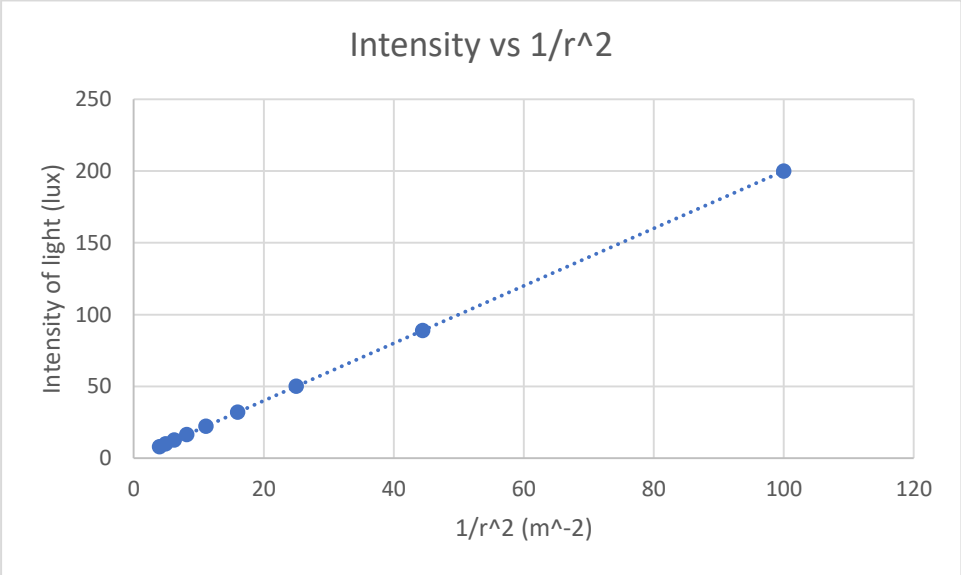

Figure 3 – Intensity of light vs inverse square the distance from the source

Students should do the same for the second part of their experiments using the light meter.

Problem solving and discussion

Students will explain their findings and whether it agrees with their hypothesis or not. They should be able to write a formula showing how light intensity changes with distance from the light source. Something like

$$I\alpha\frac{1}{r^2}$$

Or

$$\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$$

can explain this relationship.

Sources of error in the measurements could be due to:

- A change in the ambient light intensity (ambient light is the surrounding light such as light coming from a window).
- Inaccuracy in distance measurement.
- Not keeping the sensor at the same level while measuring light intensity.

Students can compare the results obtained using the smart phone application to those obtained using the light meter and decide whether the smart phone application is reliable or not.

They can also compare the results obtained using different applications and decide which application is the best to use. One way to decide which is the best application is to compare the results to the light meter results. Another way is to find the number of outliers on the plot of I vs $1/r^2$, the less the outliers the best the results.

Conclusion

Students will summarise their findings and state the relationship between light intensity and distance from the light source. As an implication they will confirm whether the application is good enough to do the measurements and suggest any future work that they would love to do as an extension to this experiment.

They can present their work in a school fair or on a presentation software such as prezi to assess the reliability of the used software.

References

Link to figure 1 https://www.flickr.com/photos/blakespot/3030107334/in/photolist-5BL6kU-7DhbKd-db1tru-a7GvmW-UuPxGS-88azRd-21ezFFh-a7DBj8-6DejK4-4iFBz9-bttwtV-9da1Eu-6yvF3N-9zfmtN-dSwNUm-9WD8CV-bttwuP-btSgng-bttuZZ-55qUVd-btQ1K6-bbvVpZ-cwGY27-cwGAkW-8U5oVT-bttLAi-btR5JK-6mCuGG-9Sfv9E-bttx5k-9d6UqT-oaX49s-bttv6X-btSctv-poPhUJ-qw48wg-dQnZSP-cwG2xj-9t38Uh-btPsug-bxn1RR-9d6TVM-cwGSAq-cwH7if-nTwTvG-dwLcre-bttD9F-cwGHKU-9LR2uf-9d6U4g Author Blake Patterson Licence https://creativecommons.org/licenses/by/2.0/