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Why do the images behind the paper become blurry?—the answer

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Abstract

In my previous article (Temiz B K 2020 *Phys. Educ.* **55** 027002), I demonstrated that images on a screen covered with paper are seen clearly when the paper is close to the screen but become blurry when the paper is moved away. I wanted you, the readers, to find the reason behind this phenomenon. In this study, I aim to give the answer to this question.

If a piece of paper is placed on a computer, television or cell phone screen, the text behind the paper can be easily seen (see figure 1).

If the paper is moved slowly away from the screen, the images start to become blurry and become completely indistinguishable at a certain distance (see figure 2).

In this experiment, it is observed that as the paper is moved away from the screen, i.e. the light source, the images both begin to increase in size and become blurred. The reasons for this can be explained when the events that occur as the light comes and goes through the paper are examined. These observations are associated with changes in the intensity of the light beam.

When we cover the computer/phone screen with paper, some of the light transmitted from the screen is absorbed as it passes through the paper. The transmitted light allows us to see the image as it reaches our eyes (see figure 3). The decrease in the intensity of the light beam passing through the paper can be explained by Lambert's law of absorption. Lambert's law of absorption argues that when a beam of light passes through an absorbing medium (like paper), its intensity decreases exponentially as the length of the absorbing medium increases [1].

Therefore, whether we can see the images on a screen that has been covered with paper depends on variables such as the brightness of the screen (I_0), the thickness of the paper (x), and the type and texture of the paper (α).

Why do the images increase in size and become blurry as the paper is moved away from the screen? The increase in size of the images on the paper is due to how the light beam emanating from the screen spreads and diverges, because the digital images formed on computer screens are created by light cells called pixels. Each pixel, composed of three different subpixel cells (red–green–blue), can be considered as a light source. The gradual blurring of the images on the paper can be explained by the decrease in the intensity of light. As a surface moves

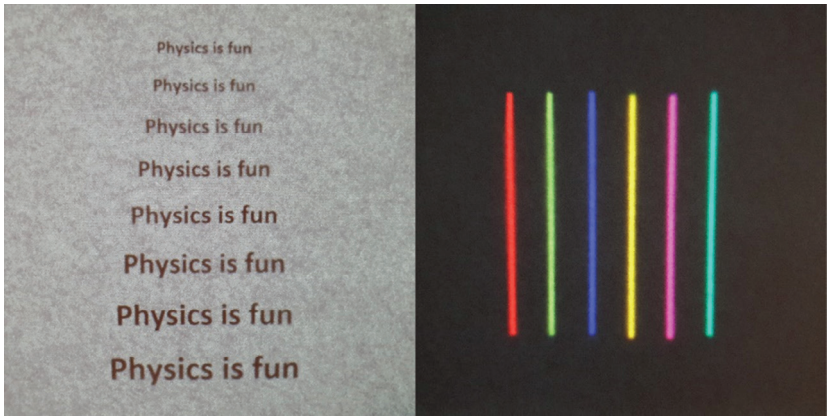

Figure 1. The view of images on a screen behind the paper placed on the screen.

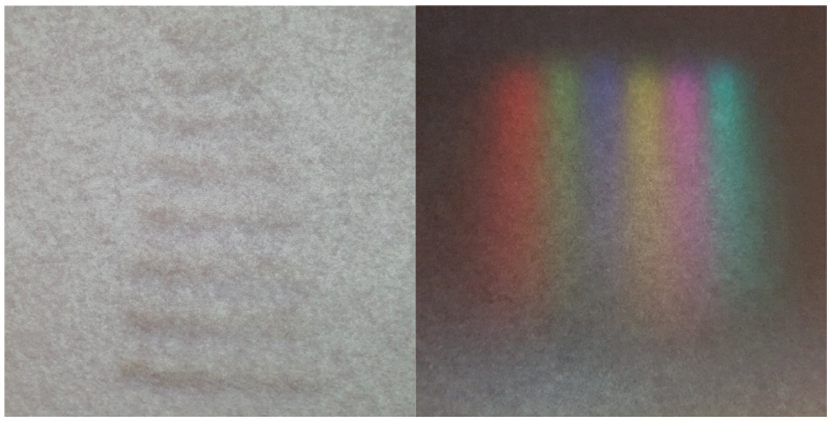

Figure 2. The view of images on a screen behind paper moved away from the screen.

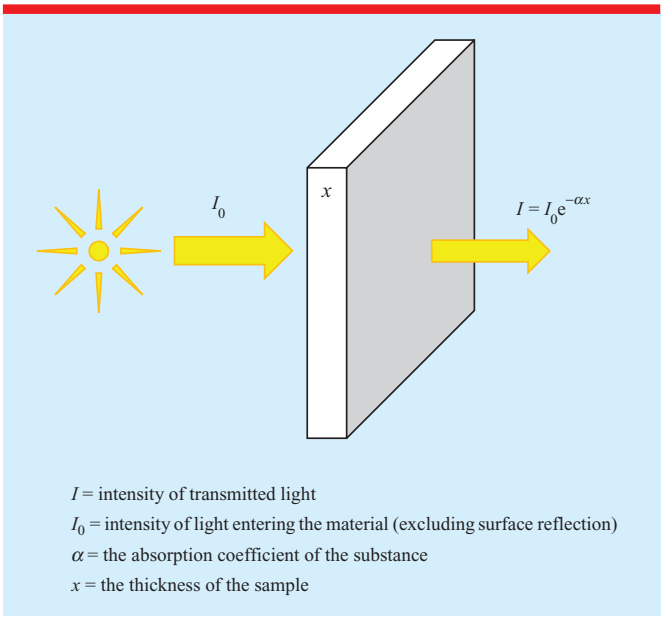

Figure 3. Lambert's law.

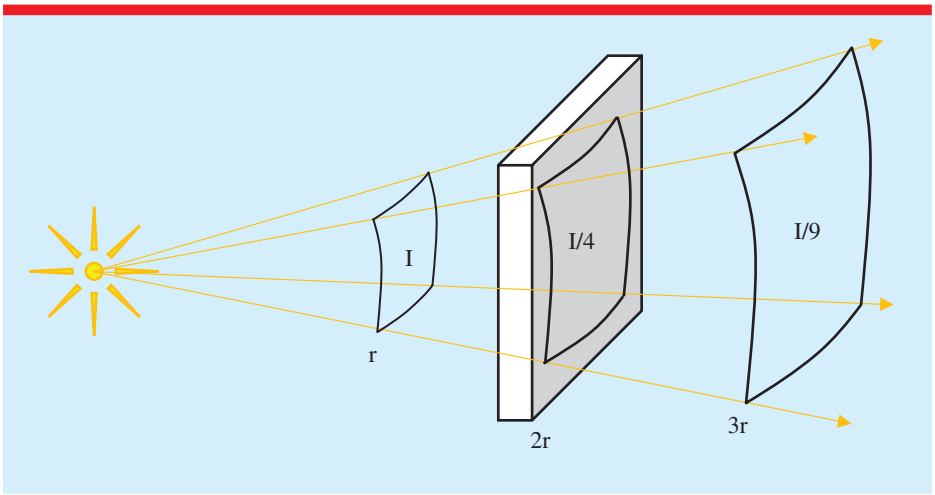

Figure 4. Illumination of a surface (the inverse-square law).

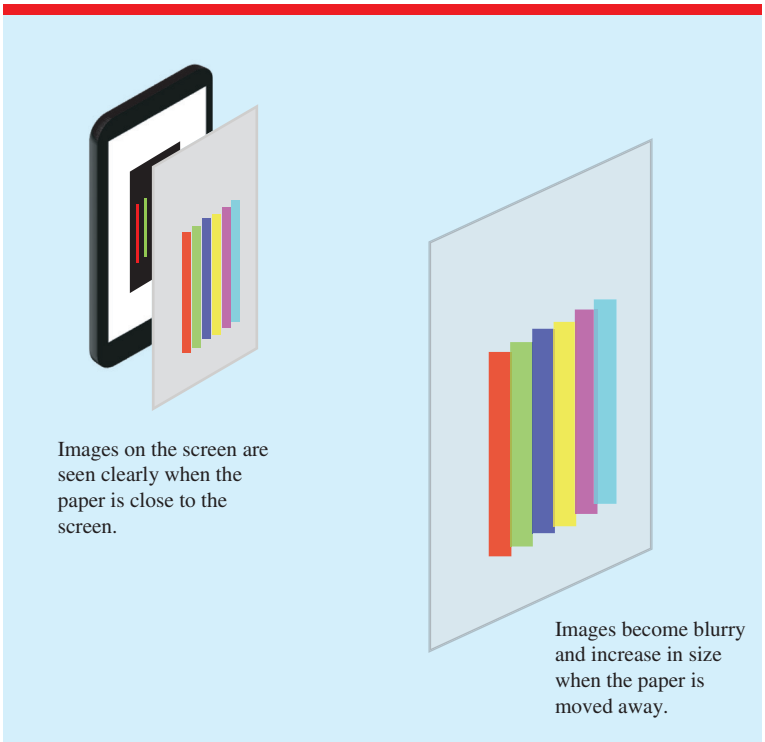

Figure 5. The view of the coloured lines on the screen behind the paper at different distances.

away from a light source, the luminous flux per unit area, i.e. illumination, also decreases (see figure 4).

As a surface that is illuminated by a light source moves away from the light source, the surface appears dimmer. As the paper is moved away from the light source, the intensity of the light entering the paper (I_0) decreases and the images on the paper become blurry as they increase in size (see figure 5).

In this experiment, the intensity of the light coming from the screen (the light source) and reaching the human eye by passing through the paper decreases due to both divergence and absorption. At a critical distance, the images on the screen become invisible. The colour, texture, and thickness of the paper and changes in the brightness of the screen affect the observation.

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Reference

[1] Taylor A E F 2000 *Illumination Fundamentals Rensselaer* (Renssealaer: Polytechnic Institute Lighting Research Centre) pp 17–24

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