Unit 1: Optics – Light & Color
Project 2

Make Your Own Animated Movie

Have you ever wondered how an animated movie is created? How do pictures become alive in front of our eyes? Follow us through the process of creating your own animated movie, by using a very simple device (stroboscope) that you will build yourself and find out the answers to these questions or the ones that were troubling you so far!

Degree of Difficulty

Experimental: Easy
Conceptual: Moderate

Objectives

Completion of the activities should enable you:

- to construct your own stroboscope
- to understand the principles underlying the stroboscope
- to be able to produce sets of pictures (flick-book figures) showing physical phenomena or physics laws
- to be able to explain the practical applications of a stroboscope

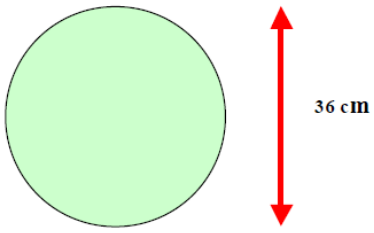
Materials: scissors, stiff cardboard, pins, scotch-tape, meter stick, a wooden handle (a piece of wood - 1.5cm x 2cm x 25cm), mirror, bolt, 2 washers, two nuts, one lock nut, permanent marker, drill.

Procedure

Constructing the stroboscope

1. Take the stiff cardboard and cut a disk with a diameter of 36cm (see figure 1).

Figure 1

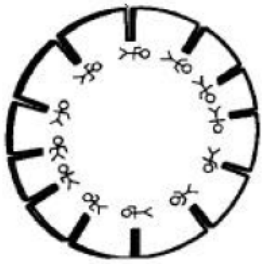


2. Mark off about twelve equal spaces along the periphery of the disk.

3. Cut a slit about 2x3cm (starting from the periphery – 3cm along the radius) for each one of the marked points of step 2 (see figure 2).

4. Draw a set of flick book pictures, one under every slit (about 1cm underneath the slit), with their head facing right (see figure 2).

Figure 2

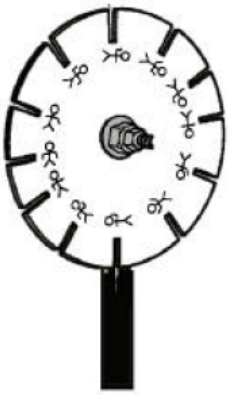


5. Make a single hole at the center of the disk, equal to the diameter of the bolt that is available (You will use the bolt to attach the disk to the wooden handle).

6. Take the wooden handle (1.5cm x 2cm x 25cm) and drill a hole, equal to the diameter of the bolt that is available, at one of its ends.

7. Attach the center of the disk (after you make the slits and draw the flick book pictures) to the wooden handle (the disk will be parallel to the handle). First, insert the bolt into the wooden handle hole and fasten it with a nut. Second, pass the bolt that is already on the handle through the center hole of the disk. Third, fasten the disk with a second nut and lock the second nut with the use of a third nut ("lock nut"), (see figure 3).

Figure 3



8. Put your device (stroboscope) between one of your eyes and a mirror (the mirror does not have to be of particular size, but must be big enough for you to see clearly the flick-book pictures in it) with the revolving figures facing the mirror.

9. Hold with one hand the wooden handle and with the other one spin the disk. Look through the slits of the stroboscope at the pictures in the mirror, as the disk is rotating.

Activities

1. Look through the slits of the stroboscope at the pictures in the mirror, as the disk is rotating. Change both the rates and the direction of rotation. What do you observe?

2. How does this phenomenon relate to slow motion photography or speeded up photography? (Physics books and internet would be helpful)

3. Draw a new set of flick book pictures, one under every slit (about 1cm underneath the slit), with their head now facing left instead of right. Do you observe any differences? How about if you draw the top towards the edge?

4. Use your stroboscope to observe a spinning wheel of a bicycle.

    - What do you observe when rotate your stroboscope in the same direction as the spinning wheel?
    - What do you observe when rotate your stroboscope in the opposite direction as the spinning wheel?
    - What physical value relates to the rotation rate of your stroboscope?

5. Design and perform experiments to answer the following questions. Your experiment's lab report must include: Title, Purpose, Equipment, Procedure and Data Collection, Data Analysis, Results and Conclusion. The Data Collection is the most critical part of a laboratory experiment. You must follow a *systematic research method* to secure valid answers to your questions. In a systematic research method you define, (a) your independent variable (the variable that is controlled by the researcher and is being changed, increased or decreased, in order to measure any changes regarding the variable we are interested in – It is suggested to change the independent variable by equal increments), (b) your dependent variable (the variable that is under investigation and depends upon the changes of the independent variable), (c) control variables (other variables that you assume that their presence might affect your experiment and therefore, you keep them constant throughout the whole experiment).

    - Can you make the spinning wheel of a bicycle seem to stop turning? Can you make it seem to turn in the opposite direction it rotates (backwards)?
    - How does the angular velocity of the spinning wheel relate to the angular velocity of your stroboscope in each one of these two cases? We use the term *angular velocity* to refer to the rate with which the rotating body (i.e. wheel) is rotating. If

you have more questions regarding this physical value, ask your science teacher to help you.

- Is it possible to make the wheel seem to spin faster than it actually is?

6. Follow steps 1 to 4, and 8 to create a new stroboscobe. However, instead of drawing flick book pictures on the disk, divide one of its surfaces in three equal areas/pieces (it will look like a pie graph). Paint the first piece cyan, the second magenta, and the third yellow. Put your stroboscope between one of your eyes and a mirror. Look through one of the slits at one of the colored pieces.

    - Try to rotate the two wheels with the same angular velocity (at this point you will probably need someone to rotate the two wheels for you). What do you see? Are you able to see all colors? If no, how can you see the rest of the colors? Explain your reasoning and report any mathematical calculations you might make.
    - What if the disk is divided in more than 3 equal pieces? Will it take the same time as before to see a second colored area? Explain your reasoning and report any mathematical calculations you might make.
    - What do you see when the angular frequency of your stroboscope is much less than the angular velocity of the colored spinning wheel? Explain your reasoning. Change the colors of your colored wheel. Do you observe any differences? Explain.

7. Create a second spinning wheel for your stroboscope, where you present a physical phenomenon. For example, show how a feather and a stone will move relatively to each other, when you drop them from a certain height. First, assume that the air resistance is negligible and then show how the two items will move with the presence of air resistance. You are encouraged to create more flick-book pictures for your own ideas.

8. Create another spinning wheel for your stroboscope, where you use more than one color to color parts of the item you are sketching. For this part you have to be systematic. For example, start with one stationary item painted with one color, then use two colors (one every other picture), then use three colors (one every two pictures) etc. Make sure that each time you are adding a color you make the corresponding observation by rotating your stroboscope. It is suggested to create a two-column table where you report the colors you used for your picture and your observation.

9. Design a set of flick-book pictures where you present a stationary wheel spinning.

Final Project/Report

Your have been asked to write the manual of the stroboscope, by a major company. You have the freedom to make your own selections concerning the content of the manual. Do not forget to summarize all the experiments and the activities you have

performed in this project. Have in mind the manual must be descriptive and understandable by people that have never used a stroboscope before. Therefore, sections about how to build the stroboscope, how to use the stroboscope, and how/why the stroboscope works are strongly suggested to be included within your manual. Use of diagrams or pictures are strongly suggested. At the end of your manual give examples of possible applications of the stroboscope in our everyday life.

Reference

Smith, G. and Holloway, G. (1985). *40 Science Activities*. London: Macmillan Education.