Newton Day 2009
Celebrating 367 years of Sir Isaac Newton

by Peter Mao for Margaret

pre holiday draft

Abstract

Sir Isaac Newton, was born on December 25, 1642, or January 4, 1643, depending on your calendar of choice. The Brits of the time used the first one. This year is Maggie's fourth Newton Day and we will crack *Opticks* for the first time. Specifically, we will use color filters and prisms to explore color mixing and the difference between spectral colors and composite colors.

1 Inspiration

> "Colors may be produced by Composition which shall be like to the Colours of homogeneal Light as to the Appearance of Colour, but not as to the Immutability of Colour and Constitution of Light. . . . There may be Colours produced by the Composition, which are not fully like any of the Colours of homogeneal Light."
>
> *OPTICKS Book I, Part II, PROP. IV, Theor. III*

This year's topic was informed and inspired by a talk given by Jeremy Nathans at MIT titled "The Evolution of Trichromatic Vision."[1] Nathans points out that Newton was the first to discover that mixtures of spectrally pure colors can appear the same to the human eye/brain as spectrally pure colors. For example, projecting green and red light onto a white wall will appear yellow to most humans. This is exactly the phenomenon that televisions and monitors use to display a full spectrum with only three colors, usually red, green and blue.

Newton did not explain the physiology of trichromatic vision – that had to wait a few centuries for Thomas Young and Hermann von Helmholtz to come along. Today, we understand that the human eye consists of two types of receptors: rods, which handle low light conditions and have their peak sensitivity near 500 nm, and cones, which give us color vision. The cone receptors come in three types, giving the eye three broad band detectors covering the visible spectrum (roughly 400 to 700 nm). The perception of color, then, depends on the relative degree of excitation of the three types of cone receptors. Hence, red and green mixed in the proper ratios can look identical to a spectrally pure yellow.

2 Activity 1

Materials:

- 2-3 flashlights
- color filters

[1] `http://mitworld.mit.edu/video/669` See the part from 8:20 to 13:50)

- prism

Newton used multiple prisms, apertures, mirrors and lenses to prove that while one could produce, by mixing different colors of light, the appearance of spectrally pure (homogeneal) light, the composite light was, in fact, physically different from the homogeneal light in that the component colors could be separated out again.

With the color filters and the flashlights, we shall project different colors on a white surface and make note of the apparent colors.

If a bright enough light source is available (i.e., it is sunny on Newton Day), we may attempt to observe the spectral bandpasses of the various filters.

To complete the Newtonian exercise, we should verify that the mixed light can be separated back out into its components, but I suspect that beam divergence will cause us to lose too many photons.

3 Activity 2

Materials:

- cathode ray tube with color phosphors
- couch

Another way to observe the mixing of colors is to use a household cathode ray tube. Most cathode ray tubes produced in the recent past are the color type, with a repeating array of three color phosphors. The electron beam excites the phosphors; by controlling the degree to which the phosphors are excited, one can produce most of the colors perceptible to the human eye. Plasma and liquid crystal displays work in a similar fashion to the cathode ray tube displays.

4 Sources and Resources

- light sources: the sun, Light & Motion Commuter light
- filters: Edmund Scientific, acrylic filters and Rosco filter swatch book
- prism: from a shop at Dulles Airport
- Hall, A. Rubert, *All was Light:* An introduction to Newton's *Opticks*. Oxford 1993.