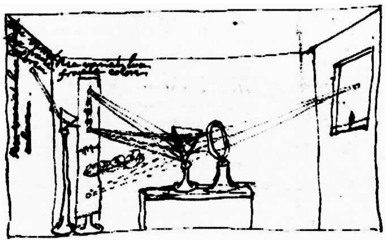
Syllabus for HNR250/PHY200, *Seeing Light*, Spring 2007



Newton's *Experimentum Crucis*

Instructor

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Prerequisites and administrative information

This course has no science prerequisites. We will use some algebra, scientific notation (powers of 10), and trigonometry, but this course does not require a calculus course.

This 3-credit course is listed as an Honors (HNR) course and with a grade of "B" or higher can be used to satisfy the breadth and quantitative/creative expression Honors requirements. It is also listed as a PHY course and can therefore count towards the lower division portion of a degree in Physics. This course counts as a lab science course for Arts & Sciences and may also satisfy lab requirements in other colleges.

Course goals and content

My goal is to change how you "see". I hope that you will gain a deeper understanding of light and vision that you can apply to your interests and to your experience. We will also discuss how science as a discipline operates and give you practice in "seeing" through experiment.

We are going to study questions in light and vision: what is color? do all of us see the same colors? can satellites read car license plates and how do they tell us about climate change? what makes a rainbow? how do big screen TVs make an image? why can nothing go faster than the speed of light? how does light interact with matter?

Light is essential to most people's experience of the world: the information passed through our eyes is much greater than that from other senses. It is both a central tool of and a subject of study in science.

The highlights of what we will do are

1. Study how notions of light and vision have evolved over the last 2500 years. People have had some crazy ideas about light and vision, at least from our current viewpoint. But this is how scientific theories evolve and such evolution will be a central point of the course.

2. Study the geometric aspects of light: how it can be described by rays and how it can be described by waves.

3. Learn about color. We will study the spectrum of visible light and properties of light sources, objects, and our eyes allow us to understand perceived color, which is extremely rich, but only a coarse description of light.

4. Study applications of light to atmospheric effects, photography, and display technologies.

5. Review what experiments over the last century have told us about the quantum mechanical nature of light: light is a "wavicle" (combination of wave and particle; a photon) whose behavior is fundamentally unpredictable! We will also see how light tells us that space and time are deeply connected.

6. See how light tells us almost everything we know about the Universe outside of our solar system and what it tells us about the early history of the Universe.

Resources

Required Book

The book simply titled *Light*, by Michael Sobel (1989, University of Chicago Press) is a solid introduction to the study of light and vision. Though most of our reading is outside of this book, it will be useful to have a single complete text on these subjects and we will read most, if not all, of Sobel's book.

Books

I list here books that I use as resources for this course and which are on reserve in the Physics Library:

Empire of Light, by Sidney Perkowitz (1998). This is a modern overview of light by an experimental physicist.

Color: Why the World Isn't Gray, by Hazel Rossotti (1985). The focus of this book is, not surprisingly, how light is affected by objects and how the composition of light gives perception of color.

Color and Light in Nature, by Lynch and Livingston (2001). This book has beautiful examples of natural phenomena, including a huge variety of rainbow/halo phenomena, aurora, twinkling stars, and other atmospheric effects.

The Fire Within the Eye: A Historical Essay on the Nature and Meaning of Light, by David Park, whose title says it all.

Colour: Art & Science, edited by Trevor Lamb and Janine Bourriau. This is a collection of essays on color and its role in art.

Light and Color in Nature and Art, by Samuel J. Williamson and Herman Z. Cummins (1983).

Introduction to Light: The Physics of Light, Vision, and Color, by Gary Waldman (1983).

Web

There is a lot of information on light, color, and vision available on-line, of course. Two types of resources that will be of particular interest are primary source material, such as essays by Plato on light, and simulations of the behavior of light and color. These links will be made available through BlackBoard (`http://blackboard.syr.edu/`).

Assessment of your work

Some work, especially logs of your experiments, will be submitted on paper. Much of your written work can be submitted via Blackboard. Please submit such work in the area marked "Assignments".

I use the course grade to indicate how well I believe you have truly learned the course material. If your submitted work and participation indicate that you can remember and apply the ideas developed in the course, you will receive a grade of "A". If you can mostly apply the ideas, but don't demonstrate a complete grasp of what was developed in the course, you will receive a grade of "B". My estimate of how well you understand and apply the ideas will be based on the following assessments, with their weight indicated in brackets:

- [5%] Reading logs: For each reading assignment, you are to use BlackBoard to submit a short summary (8-12 sentences) of what you read *and* a list of two or more questions about the content of the reading, before class starts. [Late reading logs receive zero credit.]

- [40%] Lab notebooks. Purchase any style of book you like - the "Marble Cover" books are cheap and easy to carry around, but have small pages. Large traditional lab books are also fine. Your choice. You will maintain two (2) lab notebooks that will be a record of the experiments that we carry out in class and those that are assigned for out-of-class completion. I will announce when I will collect them, swapping one of your lab notebooks for the other. In addition to these regularly assigned labs, you are expected to complete three (3) "opportunistic" labs (a list will be handed out in the second class). I will give examples of what I expect, but the main principle is that your notes should be a clear record of what activity you carried out, with diagrams of equipment and observations, instructions (procedures and motivation), and a discussion of your results. Note dates and times of observations. A lab notebook is a log of what you do, written in a way that others (or you at a later time) can reconstruct and follow what you did. [Lab scores are reduced 20% per day late.]

- [20%] In-class exams. I will give a mid-term and final exam, which will ask you to discuss concepts developed in class, supported by examples and diagrams. The mid-term and final exams will be of equal weight and will be designed to be completed in about one hour. [I need a valid medical excuse or true emergency (not a job interview, for example) to reschedule an exam and rescheduled exams will be conducted interview-style (that is, oral, nonwritten exams).]

- [25%] Course project. This project will consist of writing a paper to support your research into a particular topic of light and vision. This project should include some demonstration of physical principles or involvement in activity where the understanding of light plays a central role. The grade for this work will be based on a proposal [5%], a draft [10%], and a final project [10%], developed throughout the second half of the semester. I strongly recommend that you spread out the work for your project as much as possible. [Course project components are reduced by one grade level (e.g., A- to B+) for each late day, with the first grade reduction taking place at the time they are due.]

- [10%] Participation in class activities. If you actively participate in most of the class discussions, you will receive full credit here. If you miss a noticeable fraction of class meetings, this will be reduced. Discussion with others is necessary to truly appreciate new ideas.

Collaboration, sources, and academic honesty

I encourage you to share ideas with your peers both in and out of class by active discussion. I wish to emphasize that science and knowledge in general advance by discussion and sharing and bouncing ideas off of one another and by reading a wide variety of sources. So no source of information is "off limits".

The key principle, then, is that you should properly **acknowledge all of your sources** in written or online work. Sources include web pages, books, articles, television shows, and people. For example, if you learn something from someone, you should credit them in your paper or lab notebook. Examples:

- “Jes Katt suggested that I try this out, which worked out well because I saw a new color at the edge of the sample.”
- “The principle of pair production (Ref. 23) means that colliding light beams can create matter.” [Or, alternately, “The principle of pair production [Sniffler, 1986] means that colliding light beams can create matter.”]
- “This figure is a screen capture of a tutorial simulation of light reflection that can be seen at `http://www.microscopy.fsu.edu/primer/java/reflection/reflectionangles/`.” (please be cautious, using only reliable persistent web pages).

Such acknowledgement allows the reader to track down the sources of information to learn more, to evaluate the reliability of the information, and to see that others are properly credited for their efforts. A consequence of this principle is that quotations from sources should be clearly indicated as such, by offsetting long quotes and including short quotations in quote marks. The principle of acknowledging your sources is central to scientific writing; a large fraction of sentences have citations. This principle avoids plagiarism and makes your work more useful.

Except for properly acknowledged quotations, all work that you submit should be in your own words.

Improperly aiding another student is academically dishonest. Please do not share your written work in any manner, even by e-mailing your work to another student, as you will be held responsible for contributing to academic dishonesty if someone else turns in your work. Please also be aware of the details of University and College policies on academic dishonesty.