

2006-83: LIGHT AND THE ARTS: A CLASS FOR ENGINEERS

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Light and the Arts: A Class for Engineers

Abstract

An exposure to the arts is an essential part of every undergraduate's curriculum, but we feel that the course offerings adopted by most universities to acquaint their engineering students with the fine arts fail to meet their objective. Herein we describe a different type of fine arts course for engineering students which approaches the subject matter through an avenue that they can see as valuable and empowering. The key objectives of the course are to approach the subject of fine art from a perspective where technology-oriented students would have an advantage, rather than a handicap; to exploit the experience so as to reinforce some aspect of engineering science by reviewing it in a new context; and to place the engineering students in an environment composed mostly of others in the same discipline.

Background

Although many engineering students would argue otherwise, an exposure to the arts is an essential part of every undergraduate's curriculum. This is underscored by its de facto inclusion, in some form, in the required "distributional elective" hours imposed by virtually every degree program in the United States. Educators recognize that many young people who select technology as a career objective at an early age tend to nurture a technological perspective in all they do, and thus neglect to develop their artistic side.

The unpopularity of the university's attempts to compensate for this derives, we propose, from the ways in which they are implemented. In most institutions the technologist's introduction to fine art takes one of two formats: a first course in an intended sequence, or a survey course for nonmajors.

The Introductory Course of a Sequence for Arts Majors

Engineering students typically shun this type of course because, upon being injected into a environment studded with many classmates who possess a gift for drawing and a heritage of art appreciation/experience/knowledge, some of whom are themselves budding artists, the engineer feels (and is) handicapped. He/she fears that the diversity acquired will come at the cost of hurting his/her grade point average.

The instructor can assuage this somewhat by using an "A for effort" grading policy, as is done in physical education classes to avoid biasing grades for the athletically gifted. But this is less than satisfactory. Who among us feels any sense of pride in his A in "Basketball 101" when he can't make the school team?

The Survey Course Designed Especially for Engineers

Many instructors have a condescending attitude towards survey courses, considering them "watered down" and not genuine parts of the curriculum. Students in these classes may tend to acquire a lifelong perspective of an "observer" of the discipline, with no prospect of ever being a participant, a connoisseur, or an enthusiast.

Herein we describe a different type of fine arts course for engineering students which approaches the subject matter through an avenue that they can see as valuable and empowering. The key objectives in course are to approach the subject of fine art from a perspective where technology-oriented students would have an advantage, rather than a handicap; to exploit the experience so as to reinforce some aspect of engineering science by reviewing it in a new context; and to place the engineering students in an environment composed mostly of others in the same discipline.

General Features of the Course

The first and foremost goal of this course is to impart an appreciation for fine art in our students. In a sense, it is comparable to a physical education course, where the student learns new types of recreation. We view the appreciation of fine art as a recreational, not a professional, activity for engineers; but (as with skiing) some instructional guidance is necessary to get started.

The novelty of our approach is that the instruction is imparted through venues that are familiar to and biased towards engineering majors. Rather than discuss color through the traditional artist's notions of "hue," "brightness," and "saturation," we take advantage of the technologists' skills and focus on wavelength, amplitude, and degree of polarization. We consider technologies that can detect forgeries, achieve lighting without damaging materials, enhance artists' productivity, and open new pathways for the practice of artistic endeavor.

A very valuable spinoff of the course is that it provides a review that reinforces the students' grasp of the basic principles of optics and light. Although such skills are downplayed in most engineering curricula, they remain important in the industrial sector, and we take a secret pleasure in the fact that we can "double-dip" distributional credit requirements by inserting this review into a humanities course. Half of a typical one-hour test will be devoted to identification of about 25 images, and half to (rather elementary) questions about the relevant technology; the latter may require ray tracing for a lens system, estimation of stress in a rescaled sculpture of David, additive and subtractive color mixing, rainbow features, etc.

Specific features of the course

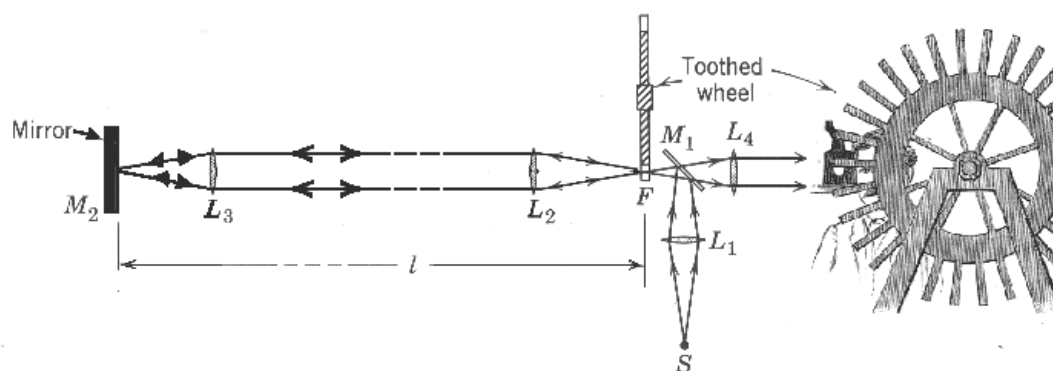
We list some specific topics and approaches that characterize the course.

Early Theories of Light

An interesting perspective is obtained when one compares the thinking of the ancients with one's own childhood perceptions of light. Such issues as whether light is emitted by the object, by the eye (as promoted by Superman comics), or by illumination sources, and how it is detected, had to

be resolved by the ancients hampered with primitive instruments and religious taboos against dissection. Michaelangelo's depiction of Moses' "rays of splendor" is an example of the early misconceptions. See <http://en.wikipedia.org/wiki/Image:MichaelangeloMoses20020315.jpg> and <http://www.moseshand.com/studies/moses.htm>

From an engineering viewpoint, the ingenious apparatus devised by Fizeau to measure the immense speed of light propagation using the ponderous equipment of his time is inspirational.



(from H.Watts' Manual of Chemistry, publisher unknown, circa 1842)

Color and the Wave Nature of Light

Destructive interference, the backbone of the wave theory of light, can be demonstrated inexpensively in the classroom simply by taping a hair across the opening of a laser pointer (in fact this was much like the original setup used by Young - not a double slit!). Such sites as <http://micro.magnet.fsu.edu> and <http://kiptron.psyc.virginia.edu> contain a wealth of javas and images depicting many aspects of light physics. The geometry of the double slit experiment is elegantly depicted at <http://micro.magnet.fsu.edu/primer/java/interference/doubleslit/index.html>. Spectral dispersion by a prism can be viewed interactively at <http://www.up.univ-mrs.fr/~laugierj/CabriJava/0pjava60.html>.

The chromaticity diagram quantifies the qualitative descriptors used by artists. Elegant depictions are found at http://www.cs.rit.edu/~ncs/color/a_chroma.html. The artist's color wheel is displayed at http://www.sanford-artedventures.com/study/g_color_wheel.html.

Artists employ color variations to depict many effects:

Emotion

Bellows' "Sharkey's" <http://www.artchive.com/artchive/B/bellows/sharkeys.jpg.html>

Goya's "The Shootings of May 3, 1808" http://artchive.com/ftp_site.htm

Hopper's "NightHawks" http://artchive.com/ftp_site.htm

Picasso's "The Tragedy" <http://www.nga.gov/cgi-bin/pimage?46388+0+0>

Perspective

DaVinci's "Mona Lisa" http://artchive.com/ftp_site.htm

Dali's "The Hallucinogenic Toreador" <http://www.daliweb.tampa.fl.us/92.htm>

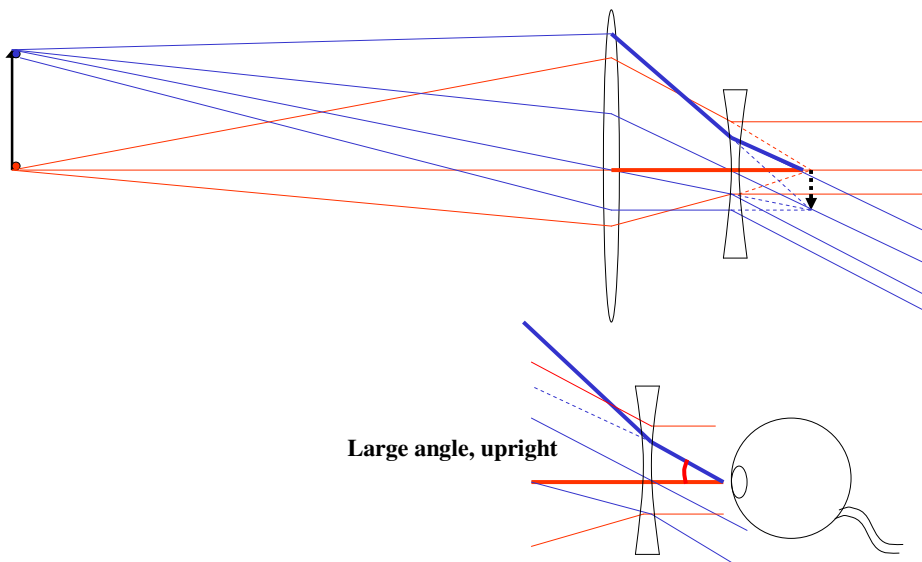
Depiction of Light Sources

Caravaggio's "The Incredulity of St Thomas" http://artchive.com/ftp_site.htm

Rembrandt's "Portrait of a Lady" http://artchive.com/ftp_site.htm

Optical Instruments

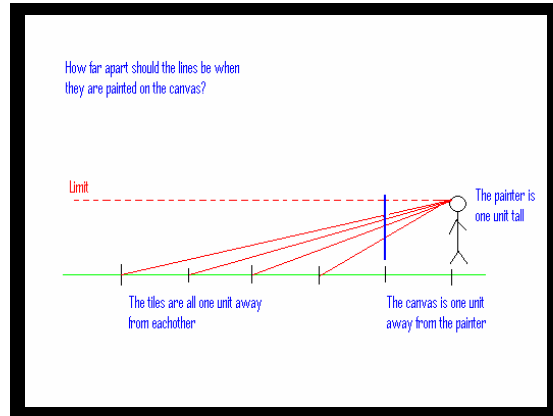
The recent controversy initiated by the artist David Hockney^{1,2} as to whether artists of the 14th century used artificial aids in constructing their work is a natural invitation to a review of geometric optic principles. Tutorials in geometric optics are available at <http://micro.magnet.fsu.edu/primer/>. Some of Galileo's original instruments can be viewed at <http://brunelleschi.imss.fi.it/esplora/>.



A particularly intriguing speculation is whether the prominence of left-handed subjects in the works of Caravaggio during one period evidences the use of a mirror or a lens for enhancing the reproduction of details. The discussion, and many entertaining as well as enlightening images, resides at <http://webexhibits.org/hockneyoptics/post/stork.html>.

Perspective

Old textbooks contain extremely complicated rules for drawing, say, a tiled floor in exact perspective, but analytic geometry can be used to derive simple formulas for the construction.



Cameras

The inner workings of cameras and the chemical processing steps in film exposure and developing provide excellent examples for students of mechanical, chemical, and even electrical (semiconductor photolithography) engineering. (It must be admitted that a lab experience devoted to reverse-engineering a commercial camera failed; one must detach 50 screws just to get to the focusing lens!) Construction of a *camera obscura* out of a discarded appliance carton (with empty, lensed, and mirrored apertures) proved to be a very entertaining classroom experience.

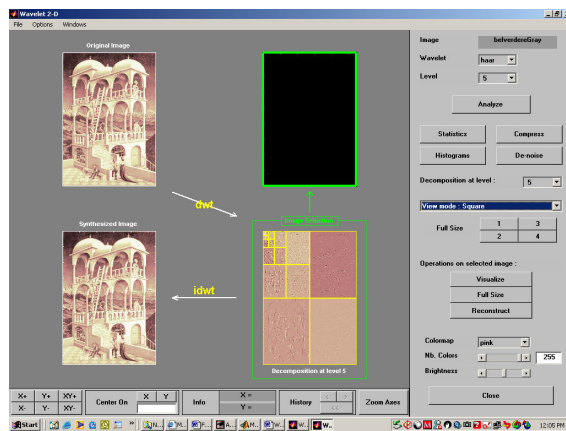
The Eye

There are two engineering aspects to the workings of the eye: the muscular adjusting of the lens for focusing at various distances (and its compensation by glasses), and the signal processing by the three overlapping-band wavelength detectors (cones and rods) that carry the perceived image to the brain. Artists can manipulate the indeterminacies resulting from the latter to paint "colors" that have no wavelength, create optical illusions, and focus attention on selected areas in a work. See <http://www.colormatters.com/colortheory.html> for examples.

Artist Identification and Forgeries

A new field of investigation^{3,4,5} has recently opened up, in which one tries to characterize artists by the wavelet transforms of digitized versions of their works. This provides students with

insights into the workings of signal analysis. A screen display constructed using the Wavelet Toolbox MATLAB® is shown below.



Conclusions

The main objective of this course is to expose engineering students to a new form of recreation - namely, art appreciation. It was felt that if they were to learn to recognize, say, 80 well-known works by 40 famous artists, they would derive great pleasure during their professional visitations to such cities as New York, Los Angeles, Washington, Paris, Madrid, Florence, London, ..., in viewing the originals in the noted museums.

In this regard, the course has succeeded measurably. At the onset of each semester we administer a diagnostic test, asking them how many of about 40 famous works they can recognize; inevitably the class average is 5 or 6. By semester's end they are scoring over 80% in identification of 100 works by 50 artists. They accomplished this with an enjoyable, nonthreatening classroom experience that also reinforced their mastery of concepts in electromagnetics, optics, and (lately) signal processing. The enrollment grows every year.

For other instructors who'd like to offer this course, the following PowerPoint modules are available for downloading from the author's home page <http://ee.eng.usf.edu/people/snider2.html>.

Speed of Light

Wavelength

Refraction

Mirrors

Converging and Diverging Lenses

Microscopes, Telescopes, and Cameras

Lens/Mirror Orientation

Perspective

The Eye

Color Theory

Others - in particular, wavelets, will be added as they are developed.

The author, an engineering professor with little formal training but great enthusiasm for fine art, has been solely responsible for the administration of the course; naturally guest speakers are enlisted whenever they are available.

The list of references contains textbooks^{6,7,8} and web sites⁹⁻¹⁷ that are particularly apropos to the course.

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