Walk-in Camera Obscura

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Type: Design Project
Length: 4 weeks
Location: Take Home

Summary

A team of students is tasked with designing a walk-in camera obscura for a visual artist. The artist will transport the camera to workshop locations to demonstrate the principles of the camera to students. This camera will allow two (2) students at a time to enter the camera and watch the image(s) form on the interior of the walls.

This project could be used as several different levels beginning in the first year engineering class. This is a fairly simple project requiring a knowledge of basic physics. However, the student quickly begins to appreciate the real world of design as economics, weight and space constraints begin to impact the solution generated in the ideation phase.

ABET Descriptors

Engrg. Sci. Content:	First Year Engineering
Type:	System
Elements:	Establish objectives and criteria, synthesis, analysis, evaluation (optional - construction and testing)
Features:	Student creativity, design methodology, formulate problem statement and specifications, detailed system description
Constraints:	Economics, safety, human factors, aesthetics, weight
Effort:	Team

Walk-in Camera Obscura

Design Task:

A local artist has requested that you design a walk-in camera obscura which can be used for demonstrating the principles of the camera to students in a class or workshop. This camera will allow two (2) students at a time to enter the camera and watch the image(s) form on the interior of the walls.

Design and build a camera obscura which satisfies the following specifications:

This camera should be light weight and portable.
It should be easy to assemble/disassemble.
Camera must be light tight.
Camera must accommodate two students simultaneously.
The image should project solely on one wall.
Camera materials should cost less than $200.

Remember, the client is a <u>visual</u> artist. Exterior (and interior) aesthetics <u>will play</u> an important role in selection of a satisfactory design.

Submit the design report and final design by COB (Close of Business) on Friday, April 15, 1989. The report should include the following:

a. Problem Statement with matrix analysis of the needs
b. Project Objective(s)
c. Target Specifications
d. Evaluation of alternatives
e. Analysis (sizes, space layout, cost, accessibility, aesthetics, assembly)
f. Table showing verification of specifications
g. Implementation (drawings, bill of materials, cost analysis, weight analysis, assembly instructions, maintenance instructions)

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Walk-in Camera Obscura

Engineering Notes

The oldest known description of the pinhole is attributed to Mo Ti in an ancient Chinese document in 400 B.C. In the West by 300 B.C., Aristotle's writings describe the use of the pinhole. And by 500 A.D. pinhole optics were diagrammed by Anthemius of Tralles. The pinhole was used to study light rays by Alhazen in Egypt in the year 1000 A.D. By the 13th century pinholes were placed in time-calculating devices, such as a gnoman, which became the standard instrument throughout China. Pinhole optics have been used in many other applications over the span of history.

Two of the oldest descriptions of the camera obscura, or the pinhole camera, are those of Leonardo da Vinci around 1500 and Shen Kua around 1086. It is widely believed that Niepece produced the first "photograph" from an eight hour exposure in a camera obscura in 1839. Pinhole apertures for photography were first written about in the late 1850s. Pinhole photography flourished in the art world through the latter part of the 19th century and into the early 1900s. By the 1920s the use of pinhole photography waned as lens-type cameras became cheaper. But by the 1950s scientists found new uses for the pinhole in high energy X-ray and gamma-ray imaging (where lenses and mirrors fail). Today pinhole photography is a standard imaging device used in nuclear medicine, in astronomy for imaging black holes from space vehicles, and in physics for recording laser plasma.

Yet the pinhole camera can still be that FUN experience which most boy- and girl-scouts have encountered; building a camera from a light tight box with a small pinhole and producing a photograph on a piece of film or photographic paper.

The pinhole camera, or camera obscura, is still the best way to teach the principles of photography. And the best way of seeing the pinhole camera work is to sit inside the "box" and see the image form, inverted, on the wall. And to watch the image move!

Objectives/Comments:

This project could be used at several different levels beginning in the first year engineering class. This is a fairly simple project requiring a knowledge of basic physics. However, the student quickly begins to appreciate the real world of design as economics, weight and space constraints begin to impact the solution generated in the ideation phase. In addition, the simple requirement of "Must be light tight" becomes difficult to quantify and then prove without actually building a prototype.

Walk-in Camera Obscura

Expected Outcomes:

Design Process. The design team must follow a logical process in accomplishing their design. This design process must be reflected in the design report submitted by the team.

Design Report. Each team must work together to develop documentation on the design. The design report will reflect the steps taken in the design process used in solving the problem.

Prototype. The team should determine what is the best way to verify the specifications. In the case of the specification “Must be light tight”, each group must determine whether they can verify “meeting the spec” by calculation, by building and testing a test product, or by constructing a prototype.

Team Dynamics. This project does not require the team to spend a great deal of time and effort on the “technology” of the solution. The simple nature of the problem should free the students to concentrate on working as a team and accomplishing the design task. The instructor can enhance the team dynamics by spending some time in class evaluating what is happening in the teams.

Discussion/Follow Up:

The majority of the camera designs fall into one of two categories:

a. Solid walls with dovetailed corners; mechanical fasteners at the corners to connect the walls.
b. Fabric walls with a structure made of PVC pipe.

Some characteristics of the design which should be considered are presented below:

Camera Size: Hole size and distance from the hole in the front wall to the back wall will determine the projected image size, and hence, the size of the back wall.

The size of two students sitting inside the camera must be reconciled with the dimensions on the camera determined from the optics analysis.

Check that students are sitting sufficiently far away from the image so that a “normal image” is seen by the viewers.

Walk-in Camera Obscura

Transportation: Students must determine at the beginning of the project how the camera will be transported; in a car, a truck, etc. This fixes the space constraints on the unassembled camera. This also directly impacts the complexity of assembly/disassembly, and also the types of material that may be considered for constructing the camera. This initial determination will also be reflected in the final weight of the camera.

Assembly/Disassembly. Students must be very aware of how well the individual parts of the camera fit together during the assembly process. The fit will determine how much secondary material must be included to guarantee "light tightness." Simple considerations such as the acceptable number of fasteners needed to assemble the camera parts is important. Some student groups have developed designs using over 200 fasteners, indicating most in the group had not taken apart/put together hardware before. Consideration of the type of tools, and the number of tools required for assembly will also be important.

Human Factors. Comfort of the user and the art teacher should be considered. What is the proper viewing distances, seating height, and headroom distance for the viewer inside the camera? What size and weight should the camera pieces be so that the art teacher can comfortable transport and assemble the camera?

The "light tightness" requirement should also raise safety concerns. If the camera is light tight, then is it also air tight? If so, should considerations be made for fresh air exchange? Will individuals be inside the camera for a sufficient length of time so that air exchange becomes important? This can also be the place where legal issues such as liability can be raised.

Aesthetics. In many cases engineering students leave the aesthetics of the design to the end of the project. However, in this case the client is a visual artist, one who sees and works visually. When viewing the completed project the visual artist will "see" the result first and will evaluate its "functionality" later. Students need to consider aesthetics from the very beginning of the project. For example, should the student team decide to decorate the outside of the camera to look like a "camera"? If so, then the aesthetics may predetermine the camera dimensions. Cameras come in specific shapes and sizes denoting a "class of camera". Emphasize to the students that they should not be narrow at the beginning by focusing on the technology of the camera. *Products with some of the best technology have not sold because they were in non-aesthetic packages (i.e., they were ugly).*

Walk-in Camera Obscura

Weight/Stability. There are many trade-offs that must be considered by the teams in this project. One typical trade-off is between weight of the structure and the stability of the structure. Using heavier materials and sturdier construction increases the stability of the structure in wind and under renewed use. Using lighter materials for construction reduces transported weight but reduces stability of the structure. Students can consider additional ways of increasing structure stability through staking and other means.

Only a small number of the considerations have been presented here.