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Making a room-sized camera obscura

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Abstract

We describe how to convert a room into a camera obscura as a project for introductory geometrical optics. The view for our camera obscura is a busy street scene set against a beautiful mountain skyline. We include a short video with project instructions, ray diagrams and delightful moving images of cars driving on the road outside.

1. Introduction

The camera obscura has fascinated scientists and artists for more than 2000 years [1]. We demonstrate how to convert a room into a large camera obscura as part of a unit on geometrical optics. We include a video [2] with detailed instructions, along with fascinating moving images of a city street and a majestic mountain ridge in the background. The principles are easy to understand and the project combines art [3] and science to create a rewarding experience for students.

2. The ray diagram

The camera obscura is an excellent introductory example of the application of geometrical optics. Ray diagrams of geometrical optics enable students to visualize, without mathematics, many common phenomena such as shadows, eclipses, images formed by mirrors and lenses, and our camera obscura. Figure 1 shows a ray diagram of a camera obscura or pinhole camera.

The diagram in figure 1 applies to several situations. First, it can represent holding an index card with a pinhole to safely view an image of the Sun during a solar eclipse on a second card. Second, it can represent two sides of a shoebox with an image on tissue, or film in the case of a traditional pinhole camera. Third, the two sides can be walls of a darkened room in which the image is formed by light reflected from outdoor objects. This last case describes our room-sized camera obscura.

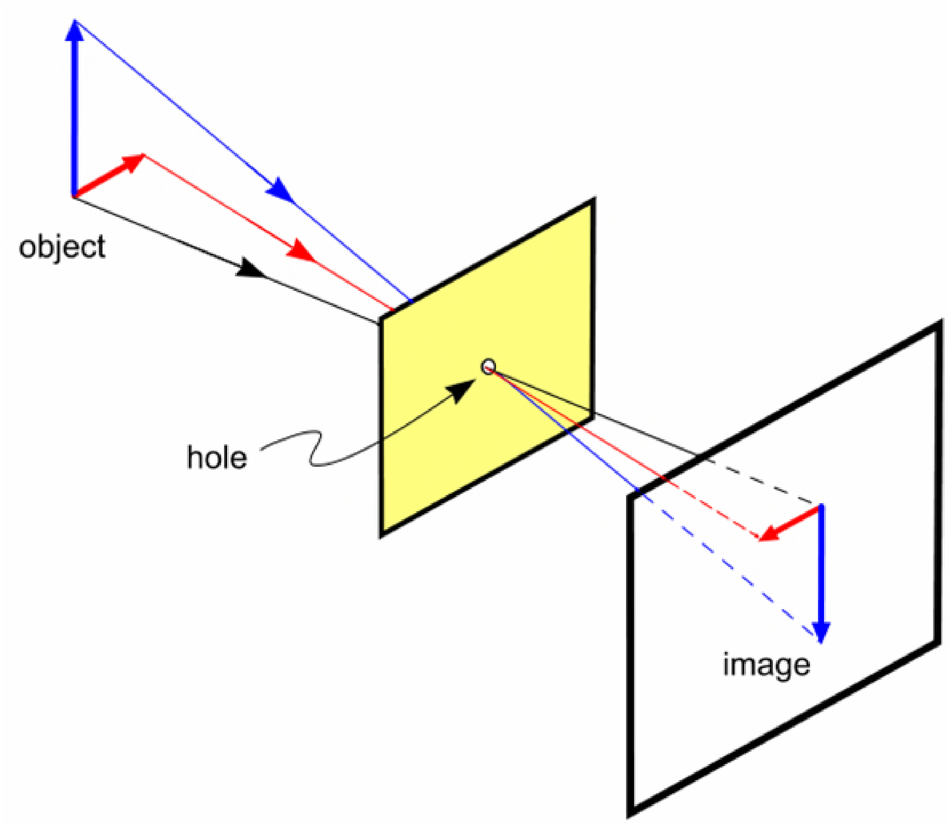

Figure 1. Ray diagram of a camera obscura.

3. Preparing the Room

For the project, one must first locate a room with a window and a clear opposite wall, so that most of the image forms on a large flat surface rather than on furniture. When we made our camera obscura, our room was the Bizamajig.com office of Ann Leigh and Billy Flynt (parents of one of the authors, HF) in downtown Asheville, North Carolina, USA. We darkened the room with large black plastic sheeting, commonly available in rolls for gardening. Be sure to test for light leaking into the room by turning off lights after the initial taping. Light leakage can easily wash out the image. Don't be discouraged if this happens on your first try. To fix our light leakage, we added extra tape in certain places and doubled up on the sheets for one window.

To create the hole for our camera obscura, instead of simply cutting a hole in the large sheet over the main window, we decided to make an exchangeable aperture unit. We cut a circular hole in a small rectangular piece of sheeting and surrounded it with a cardboard border. We then taped this section over a rectangular opening in the main sheet so we could easily exchange aperture sizes (see figure 2).

Figure 2. Aperture unit taped over a rectangular opening in the large black sheet to easily exchange aperture sizes.

The formulas for the best aperture diameter given in physics books are not helpful here, as they give the smallest size that avoids diffraction effects. Unfortunately, these apertures produce images too faint to be easily seen on a large wall. These formulas are best used as a guide for constructing small pinhole cameras where time exposures are made of the images.

We suggest taking a fun, experimental approach, and trying out different aperture sizes. The best hole size depends on many variables, such as the location, season, weather, and time of day. The best hole diameters will be much larger than the sizes given by physics formulas mentioned above. We sacrifice optimum sharpness for visibility. For a room size with hole-to-wall distance of 3.7 m (12 feet), an aperture diameter of about 2 cm, cut after tracing the hole size using a 19 mm US penny, works well at noon on a bright spring day at our location.

4. The Images

Figure 3 is a 30 s exposure of the inverted image in our camera obscura taken by one of us (HF) with a Nikon D90 digital camera.[1] The photo shows a section of downtown Asheville with a skyline of the beautiful Blue Ridge Mountains of Western North Carolina. Note the physical clock on the wall and other objects, which we intentionally left in place as visual reference points. You can see that the image extends onto the ceiling and adjacent left wall. Though one knows from theory what to expect before viewing a camera obscura, the majestic images on a large wall are impressive, and the scenes with motion, such as cars or walking pedestrians, are delightful. When making a room-size camera obscura, try to pick a location which has interesting outside activity.

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[1]The Nikon D90 photo was taken with the zoom lens at focal length $f = 18$ mm, a wide-angle shot. The equivalent focal length for the 35 mm (film) single-lens-reflex camera is $f_{SLR} = 27$ mm. The equivalent ‘film sensitivity’ is ISO 800 and the *f*-number is f / # = f / 7.1. The *f*-number determines your actual camera aperture diameter, which is $d = f / 7.1 = 18$ mm / 7.1 = 2.5 mm.

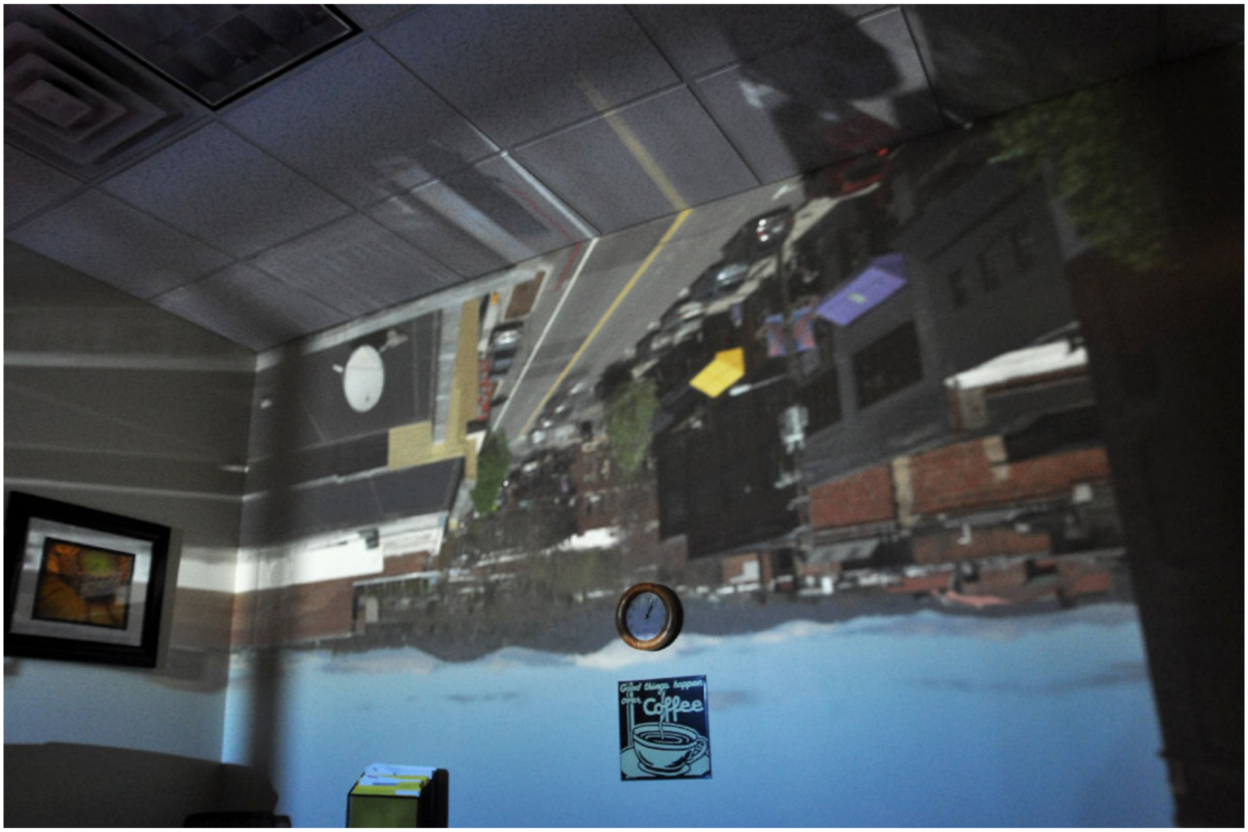

Figure 3. Photograph of Camera Obscura Image by Halima Flynt. Digital Camera Info: Exposure time 30 s, f-number f/7.1, sensitivity ISO 800, wide-angle f = 27 mm (35 mm film equivalent).

A direct view of the image on the ceiling can be found in figure 4. Since our camera obscura was two floors above the ground floor, we readily captured images from the street below. Our video includes our room preparations, image, and moving cars from the street outside.

Figure 4. Photograph of camera obscura ceiling image by Halima Flynt. Digital camera info: exposure time 30 s, *f*-number *f* / 7.1, sensitivity ISO 800, wide-angle *f* = 27 mm (35 mm film equivalent).

5. Conclusion

Talking about the theory of a camera obscura is one thing, but witnessing a real one, especially one that you have made, is a profound experience. It is a work of art[2] adds another dimension to physics. The memorable experience will surely enhance student appreciation of physics, and promote the idea that 'physics is cool'.

References

[1] Keeney C 2011 *Pinhole Cameras: a Do-It-Yourself Guide* (New York: Princeton Architectural Press)

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[2] For many examples of beautiful images with the camera obscura, see [3]

[2] The link to our YouTube video http://youtu.be/bkmCL8Ym2dU

[3] Morell A 2004 *Camera Obscura* (New York: Bulfinch Press)

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