Fun with CDs

BY JENNIFER TURNER-VALLE

If you're looking for something to do with all those free Internet CDs that arrive almost daily in the mail, here are some fun, amusing, and inexpensive optics demonstrations that make use of these and other commonly found objects.

Curved mirrors

For some simple fun, use a CD as a "fun house" mirror to observe your reflection. Fun house mirrors produce distorted images because their curved surfaces focus reflected light, just as a lens produces an image by focusing transmitted light. You can wrap a CD creating a curved mirror as the plastic substrates are flexible enough to bend a little without breaking.

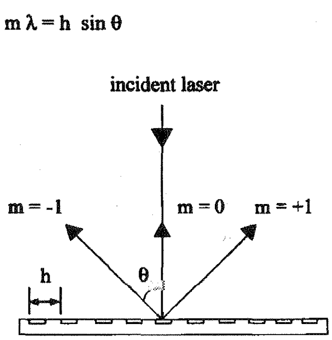

Figure 1. In the grating equation, h is the diffraction grating spacing, λ is the wavelength, m is the order number, and θ is the angle between order m and the surface normal.

Here's a good technique:

- hold the CD on your fingertips,
- place your index finger in the hole,
- bend it by pulling palmward on the hole's edge while pushing outward on the CD's edge with your thumb and remaining fingers, and
- bend until you create a concave, nearly cylindrical, mirror (it will look something like a potato chip).

Observe your reflection in the bent CD as you vary the distance between it and your face. When you pass through the mirror's focus your image orientation flips; if you align the mirror's symmetrical axis just right, your image goes from rightside-up to upside-down and back. Try playing with different amounts of curvature (both concave and convex) and mirror orientations.

Diffraction gratings

The most natural use of a CD to demonstrate an optics principle is to use the CD as a diffraction grating. Figure 1 explains how a reflective diffraction grating works: Incident light (in this example a laser) hits the grating and is deflected into different angles depending on the order number of the diffracted light.

When light hits a CD, a vivid rainbow of colors is reflected because the data pits along the CD tracks act like reflective diffraction gratings, spreading white light into its spectral components (see Figs. 2 and 3). Adjacent sections of the track function as lines in a diffraction grating, with the tracks (and therefore the grating lines) spaced at about 1.6 µm. Different wavelengths of light are diffracted into different angles because the diffraction angle depends on wavelength (see the equation in Fig. 1), resulting in a rainbow-like effect.

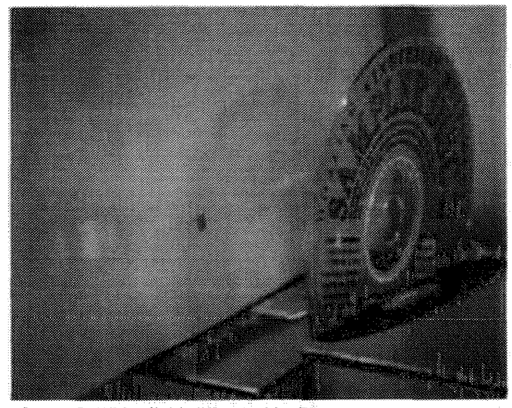

Figure 2. White light diffracted by CDs.

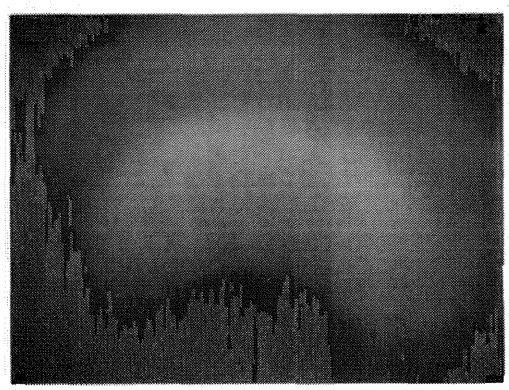

Figure 3. White light from a slide projector reflected and diffracted from a CD onto a wall.

A laser pointer—effectively a single wavelength source of light—can be used to demonstrate multiple diffracted orders. Shine the laser on the CD as shown in Figure 1. For more fun, experimentally confirm the diffraction grating line spacing by measuring the diffracted angles and using the grating equation.

Positive Lens

A surprising use of a CD is as a positive lens. It is easy to overlook the roughly 1.5-in diameter ring on the CD's underside (around the center hole), but this small ridge behaves as a positive lens. How can this be? The ring of a lens has all the image-forming properties of a lens, but it doesn't gather as much light. You will want to prove it to yourself by the following experiment to find the lens' focal length.

Use a distant bright light source, such as an incandescent light bulb or the sun, as an object. Hold the CD between the light and a white paper screen with the CD parallel to the screen and the screen oriented with its surface normal pointed at the light (just as though you're using the proverbial thin lens to form

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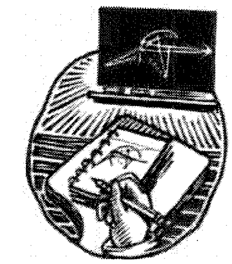

Reach Out

BY R. JOHN KOSHEL

Going into local schools to give demonstrations, hosting children for a day within your laboratory, or assisting teachers with their understanding of physics are all examples of outreach programs. There are numerous reasons we do not do these things—"I'm too busy," "I don't have the equipment," "I don't know who to call to get involved," and the list goes on. All are valid, but basically it comes down to a trepidation to start something new and unknown.

I know this feeling. I, too, felt it at one time, and I still get a bit nervous when I visit with a group of children. Many thoughts about what can go wrong cross my mind: the event will go poorly, the students will be bored, and I'll be stumped on a question. But I am here to provide encouragement and to offer you some of my experiences—both good and bad. An important thing to keep in mind is that, in the end, all events have a positive impact.

Rehearsal

Here are a few basic things that will make your outreach project more successful and rewarding—for both you and the students

- know your material
- rehearse your presentation
- locate equipment and personnel well ahead of time
- show up on time
- make it fun by getting everyone involved.

It is always good to be confident with the material you are presenting. Do your research and understand as much as you can. It is easy to fall victim to the attitude that you know about everything you are presenting; you will quickly learn that kids have a knack for asking fundamental but difficult questions like "Why is the sky blue?" and "Why do horses raise their head as you get closer to them?" Do not worry if you cannot answer everything. Over time, you will learn the types of questions that come up and will be able to answer stumpers with humor and skill.

It is imperative that you rehearse your presentation. Once you learn the material, run through it so that you are well versed in your schedule and explanations. Children often do not have the patience to wait for you to get your thoughts in order. By rehearsing, the event will run more smoothly, and your enjoyment factor will increase. I found this out recently when I tried something new during a presentation—it was not rehearsed and ended up reducing the impact of my show.

Prepare well in advance of the day of your event. You should be

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Light Touch continued

an image on a screen). Look for an image several inches below the CD on the screen.

I have found that most of my CDs have focal lengths between one to three inches. Some CDs work better than others, so if your first choice doesn't work well, try another. An impressive demonstration is to use an incandescent light bulb in a ceiling fixture as the source and your friend's Pearl Jam CD as the lens to form an image of the bulb (see Fig. 4).

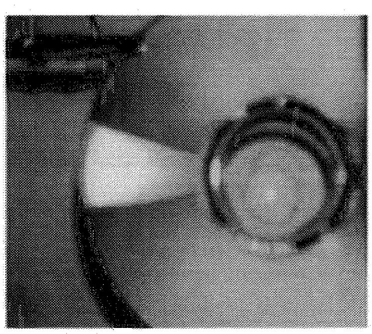

Figure 4. Image of an incandescent bulb formed by a CD's annular lens.

Once you've mastered finding the image, have some fun with it by tilting the CD to introduce additional aberrations or by changing the object-to-lens distance to alter the image size and location. If you are still uneasy believing that a small annular zone of a lens could produce an image, create your own ring lens out of a regular magnifier lens following these directions.

- Find a piece of paper large enough to cover your lens.
- Mark off two concentric circles to define a ring a few millimeters wide.
- Cut out and discard the paper ring.
- Set the two remaining pieces of paper on your lens, forming a ring-shaped opening.
- Use a distant light source to prove to yourself that the lens still produces an image.

I hope that you enjoy these simple CD optics tricks as much as I have.

Acknowledgments

Thanks to Tim Valle, Keith Kasunic, and Yakov Sidorin for helpful discussions.

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