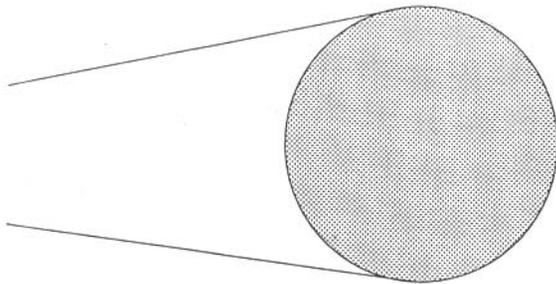


## Fun with flashlights by the fire

It's sometimes pleasant to spend an evening in front of a fireplace or campfire with kids. You turn off the TV, the radio, and the lights, and settle down for stories, talk, maybe s'mores. In these cozy surroundings, you can also entertain the kids with some interesting optics demonstrations using nothing more than a flashlight. Depending on your kids' ages and moods, you might stage a few demonstrations or you could simply point out one or two phenomena.

Start by demonstrating some characteristics of light propagation. I asked my 10-year-old daughter: If I shine the flashlight beam at a near wall and a far wall, how will it look different? She quickly (and incorrectly) said that the beam on the near wall would be brighter and bigger. (From a child's viewpoint, this makes sense, because nearer objects appear bigger.) We tried it and she saw that it was indeed brighter on the



near wall, but the beam was smaller. She correctly surmised that this was caused by the spreading of the light rays from the flashlight. I asked if she thought the shadow of my feet on the wall would be smaller than my feet, because the light would spread out from around them, or larger because the light

JANET SHIELDS, an *OPN* contributing editor, is a development engineer at Marine Physical Laboratory, Scripps Institution of Oceanography, University of California, San Diego.

would still spread out from the flashlight. She guessed right on this one. I showed her how I could make my feet dance by moving the light beam. This elicited laughter and a request to let her try.

I asked if she could think of a way to show a shadow of my feet without being able to see the shape of the flashlight beam on the wall. This can be done by holding your shirt over the flashlight. The light comes that comes through is now diffuse, but it still casts a shadow.

The next demonstration illustrated the difference between specular and diffuse reflectance. I showed my daughter that we could see the round light beam on the wall, but when we shined it on something brass, we saw only glints. That is, the shape of the beam could not be seen, because the object appeared nearly black, except for the specular reflections. At first she

thought that maybe the closer surfaces were the ones that were bright, but soon she realized that the surfaces in our direction were the ones glinting. Once she realized this, she said it must be because this surface acted like a mirror. I let her find more surfaces that glinted, or reflected like a mirror, and some that reflected like a wall. We found one surface (a hamper) that had some glint, but also had some diffuse reflection component, so that we could see the beam shape. You can explain that smooth surfaces reflect light like a mirror—a specular reflection—but many surfaces, like walls, reflect the light in all directions. Those are called matte surfaces.

We tried a game at this point. I laid a small mirror on a horizontal surface, then asked her if she could shine the light in my eyes by aiming the flashlight

into the mirror. It's harder than one might think, because the natural tendency is to change the direction of the flashlight in your hand. It's actually necessary to control both the aim (so it hits the mirror) and the position of the flashlight (so the bounce hits the target). You can make this game easier or harder by being closer or further from the mirror, and by your placement relative to the child's starting position. This is even more fun with more than one child.

One of the most fun things we tried was looking at dust particles in the beam. First, hold the flashlight in your hand so that the beam crosses from right to left in front of the child's face. Put your finger in the beam and ask her to look at the dust in the beam of light there. Once she understands and sees the dust, she can watch it floating and moving. Then ask her to whack the couch or bed and see if it can raise a dust storm. My flashlight was hot enough to heat the adjacent air when we held it still, and the particles rose quickly, as if they were in a river flowing up.

Finally, it's fun to show children how light can go through things. If you place the palm of your hand over the light, and look at the back of your hand, you can see the tendons, blood veins, and areas where the skin is thicker. The nails look brighter than the adjacent finger areas and the color of the light has changed, too. You can also hold the flashlight to your cheek, shining into your mouth, and open your mouth to make a monster face.

At the end of the evening, when you're done with optics experiments, done with stories and s'mores, and headed to bed, let the kids try to stomp on the flashlight beam. Shine it on the ground and, as they try to leap on the beam, move it just before they land. Sounds a little crazy, but my kids have loved this game for years. 