

Cloaking Device

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Synopsis of the Activity: By bending light in a very specific way, an object in the middle of the four lenses effectively disappears since the light never interacts with it. This will introduce the audience to thin lenses, and how we actually see an object.

Audience: On the late elementary to early high school age range. Works best in a museum type setting where people can come up and explore. Also possible applications to lecture format to introduce lenses.

Activity (Learning) Goals OR Learning Objectives: Participants will be able to actively explore how light is bent when it travels through a new media. Extra materials will be provided in the form of various other lenses, that will allow participants to change out the existing lenses and explore how that affects the cloaking and what that does to the light. This will encourage strand 6 participation, identifying with scientific enterprise, since participants will be forming and testing hypotheses. The activity will also provide insight into how vision works, and how we are able to see what we see.

Materials: Four lenses, graph paper, and various other lenses to encourage exploration. Simple ray tracing diagrams could be effective, equally effective would be a parallel laser source showing how rays bend through the device (currently don't have). Washers or other ring objects that disappear completely would also be a great addition. Actions figures, gemstones, and a pen to disappear would also be good. Currently using a pen propped by a paper towel roll as my disappearing object which works nicely since you can see the ends but not the middle.

Preparation and Set-up: I won't need much space, and the set up should be portable. Having a sign about what your glasses can do for you should generate more interest.

Guiding Questions: Prior knowledge: Asking if they know how their glasses work if they have them, or asking them to play with the magnifying glasses and see what can happen when they do that. What's actually happening when we see objects around us?

Engage them: Creating a sense of mystery by asking if they think it's possible to cloak something with transparent materials. Asking them what they think will happen when they put their hand in between the lenses and then asking them to compare it to what actually happens. Do they think this sort of concept would be useful and how could you scale it up? **Check for understanding:** What's happening when they use a magnifying glass? How do you think a hologram could be created?

Activity Description: I would invite people over to check out this brand-new cloaking device, and ask them if they were familiar with lenses/magnifying glasses. Then asking what they expect to happen when they place their hand in between the lenses and having them explore what happens, while giving them some background into how our eyes see the world around us. After that, allowing them to explore the world around them with magnifying glasses and having them explain what they think is happening, and why things look bigger or smaller based on where the magnifying glass is. Visitors can hop in at any point along this journey and it should lend itself to explanation. If they come in at the magnifying glass part they can explore with magnifying glasses some and then try out the cloaking device itself. I just think that the cloaking device will hook people better than others. Other good strategies would be to have some mirrors set up that create a false image to really drive home the point that we see objects by the light they scatter.

Teaching Strategies: Engagement will come first as they will be drawn into making stuff disappear. Exploration will follow as the demonstrator walks them through the set up and prompts further thought by pointing out the capabilities of the other lenses on the table. Explanation will come as the demonstrator references various everyday objects like glasses and such things. Evaluation can be conducted by asking what they think will happen when one lens is changed and then comparing it to results. It is inquiry-based as it allows the participant to drive him or herself by asking the questions, and it should raise some questions inherently to the participant.

Vocabulary: Refraction (or bending of light). Focus of lenses (point where the lens bends all the light to). Scattering (light reflecting off things).

Science Content Background and Additional Resources: Lenses bend light according the thin lens equation toward their focus. By setting up four lenses in a special way, the light in between the two middle lenses is actually focused to a tiny beam. If an object is placed in the middle of the lenses such that it wraps around that beam, or otherwise doesn't touch it, then the object will not appear when viewed from the outer lenses, creating an effective cloaking mechanism. For more information visit

<http://www.rochester.edu/newscenter/watch-rochester-cloak-uses-ordinary-lenses-to-hide-objects-across-continuous-range-of-angles-70592/>

where the technique was invented.