Jello Optics Instructor Guide

Time: 30-45 min

20 minute version: Just have them make lenses and draw how the light bends. Have them make 2 different convex lenses of different curvature and see which one has the shorter focal length:

Preparing jello: Use Knox unflavored gelatin. Use twice as much powder per water as they say. Pour into 9x13 inch casserole dishes. I would usually take 3-4 dishes to a school if I had multiple classes. You need about 1 liter of water per dish. Let sit in fridge overnight. Jello will stay solid for hours when you take it to the school. I usually hauled the Jello in a rolling cooler with some ice. Make sure jello doesn't get too close to ice or it will crystalize.

Supplies needed:

1. **Cutting utensils:** Use non-serrated butter knives and a non-serated pie slice server (to lift out chunks for each group).
2. **Freezer paper:** This helps keep down the mess. Place each group's chunk of jello on freezer paper (waxy side up) to make it easier to move jello. It also allows them a surface to draw on and mark where light goes.
3. **Protractors:** Teachers usually have this
4. **Pen/pencil:** Students should have this

Background context to lead into activity:

Ask students what they think of when they hear the words electrical and computer engineering.

Most students will mention circuits, electronic devices, wires, resistors, power lines, etc. One in awhile you will get a student who mentions something like light or radiowaves or antennas.

If no one mentions things beyond circuitry, then I tell them electrical engineers deal with everything involving the electromagnetic spectrum. I ask if they have heard of this and usually you get at least a few nods. Then I ask them to give me examples of things on the electromagnetic spectrum. Usually someone shouts out microwaves or visible light or gamma rays.

I encourage this line of thought and tell them electrical engineers work with (almost) all this (probably not gamma rays). For the example of visible light, I give the example that electrical engineers design lasers and fiber optics cables. For microwaves and radiowaves, I mention radio communication and wi-fi and 5G cell towers—all designed by electrical engineers.

We then conclude this opening activity with the emphasis that electrical engineering is a very broad field and exciting field. Today we won't be building circuits but we will actually be doing optics, which is the study of how light bends in different materials and engineers use this knowledge to design things like virtual head mounted displays.

Announcements before start:

1. Warn students there is limited jello and they won't get more, so plan carefully. Discuss how to effectively cut the different lenses shapes from the rectangle of jello without waste.

2. Encourage students to draw on the freezer paper to keep track of where the light goes. They can use a scrap sheet of paper as a target they hold up in the air to see where the light is going (and trace that path). Also let them know they will use the markings to take angle measurements in the last activity.
3. Give an activity overview. First, they will study how light bends in jello, which is called *refraction*. Then they will look at how lenses shape light in special ways. Then they will get to play with a long thin piece of jello that acts like a fiber optic cable. Finally, they will calculate the refractive index of the jello if they have time (and skill…some classes haven't had trig yet).

Warning about misbehaving students:

Some students will…

1. invariably eat the jello
2. try shining lasers at things they shouldn't
3. chop their jello into unusuable little bits and need new jello
4. steal laser points

Reduce laser pointer loss:

Stand by door at end of class and let students out door by giving back their laser pointer

Difficulties: Harder to keep students on task with this activity than building a circuit. Encourage students to draw the answers on their paper, so you can quickly check if they are understanding and also keep them engaged.

Common mistakes:

Activity 1 (light bending in rectangle of jello):

1. Some students don't take precise enough measurements and think the light goes straight through the jello.
2. Students often notice light bends but don't have enough visual spatial skills to translate their setup to the setup on paper (so can't differentiate between a and c). If I notice they circled the wrong answer, I usually draw a line on their paper perpendicular to the surface of the jello where the light ray enters the jello and ask them if the light bent closer or farther from that line. That usually corrects their mistake.

Activity 2 (lenses):

1. Students draw how the light bends in the jello, but not in the free space after the jello.
2. Some students don't cut their jello very well and have straight or jagged edges that appear to make the light go straight through the jello.

Activity 4 (refractive index calculation):

1. Remind students that the larger the incident angle, the farther away their laser pointer is from the jello and the bigger their piece of jello it is, the easier it is to make precise angle measurements.

2. Some students may have forgotten how to use protractors.
3. Make sure they are measuring the correct angle (from the line perpendicular to the surface of the jello).
4. *Sanity check for the instructor:* The angle inside the jello should be smaller than the angle of incidence on the outside. Make sure no one gets below 1 or above 1.5. Most students get between 1.2 and 1.4.