Light and Color 55 minute program (Revision: Nov 30, 2006)

> *This session requires two overhead projectors, the filter paddle kit, diffraction grating sheet(s), a slit for each projector and the sunset-in-a-jar demo materials. Preparation: using an overhead copy of their handouts will keep things parallel for them. Have markers, slits on the overheads, color filters out, and diffraction gratings set out and taped on the projectors. Pass out hand-outs – two/three per table. Optional: small gratings to distribute after class (give these to the teacher at the end of the session, (s)he will distribute them to the kids at an appropriate time).*

1. Introduction - just give first names, say we are from the Duke Physics Department, and that we get to study light and color for our jobs!

1a. Describe handouts, ask them NOT to write on them, and that they need to share with the people sitting next to them.

2. Say that we are going to ask them some questions and we DON'T want them to shout an answer - they should keep it to themselves and make notes in their notebooks.

3. Question (write on board) - How do we see things? Hint: Think about how light makes it into our eyes.

> Answer we are looking for: We see things when light from a source (such as the sun or a light bulb) reflects or scatters from an object and into our eyes. Our eyes convert the light energy into electrical signals that travel to our brain. Our brain processes this information to make sense of the world around us. They should come up with several sources such as: sun, lasers, stars, lightbulbs, flame, etc. Many of them recall that light travels in straight lines but a common mistake is that light is reflected from their eyes or somehow always fills a room. Getting the source-reflection-reception (in the eye) paradigm is the goal of this part.

4. Remind them not to say an answer. Ask them to talk about the answers with the students next to them at the table. Walk around to see what they are saying and help if needed. (no more than 3 minutes)

5. Ask for answers from each group. Write answers on the board. Do not say right or wrong. Then discuss the answer and talk about the handout. Lens of the eye, rods and cones - specialized cells that convert light energy to electrical signals. Optic nerve sends signals to the brain. Cones are specific to sensing red, green, blue light. Other colors are a "combination of these colors;" that is, they are "blended" by our brain when it receives the electrical impulses. Primary additive colors correspond to these colors.

5a. Ask them to draw in their notebook the eye diagram, pointing out the retina and the rods and cones.

6. Now on to an experiment. White light and a diffraction grating. Make a drawing on the board of a diffraction grating. Use slit on overhead. Put diffraction grating on lens.

Show rainbow on the white board. Now ask them to shout out the colors as we point to them. Teach them about ROYGBV. Point out the primary additive colors.

7. Color subtraction. Show how filters work with the rainbow to select out certain colors. Show the part of the spectrum is subtracted. Point out the primary subtractive colors. Filter with primary subtractive and primary additive.

8. Show color subtraction. Put two of the primary subtractive filters in the beam. Point out which colors each subtractive filter removes, prompt for an expectation and then show the result with both filters in place.

9. Set up two overhead projectors with slits. Use primary filters and show color addition. Have them predict which color their brain will sense. See if they can come up with the pattern that the primary subtractive colors will result. (Describe the effects in terms of what colors the filter absorbs and which colors are transmitted).

9a. Write in notebook what they are seeing. Make a list of addition and subtraction rules on the board so they can write it down in their notebooks.

9b. Use each laser pointer through the diffraction grating and onto the whiteboard. Describe the light being bent to match the appropriate color (green laser hits the green spectrum, red laser hits the red). Careful for back-reflections from the grating toward the students.

10. Discuss color addition of light in "real life:" TV/Computer/Phone screens and the pixels are RGB triplets used to display every color of the spectrum.

11. Another question: What would be the color of the sky if there was no air around the earth? (draw picture of sun, earth, atmosphere, cartoon will not be to scale, ask what is wrong with the cartoon: sun much larger than earth) Hint: Have they seen a picture taken from the moon by the astronauts?

> Answer we are looking for: Black. Look for follow up. Air causes scattering. Air molecules scatter blue light easier than red light. See if we can then get them to say why the sky looks blue. Also ask about the color of sunsets to prep them for the demo.

12. Sunset in a jar. Explain setup - water. Add chemicals. Creates tiny particles that scatter light. (bigger than air molecules, but lets it do it with just a little path). Draw diagram on board, they should draw it in their notebooks.

13. Have them predict that they will see out the edge and through the scattering water.

14. Add chemicals. This will take about 5 minutes to full develop. Have them shout out what they are seeing. Point out the blue haze (they will see it first!) and continue to check the light on the board for turning orange. The keyed in students will know something is different and may or may not be sure enough to say how it's different.

15. Wrap up. Ask what was the most confusing thing we showed them. Try to answer. Thank them for their time. It was fun working with them! Handout diffraction gratings so they can take them home and play with them: “show your family and friends!” Encourage them to describe what they learned, that will help them remember it.