Diffusion and retroreflection

FizziQ activity · Middle school · 25 min

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In a darkened room, the phone's lux meter compares the light returned by dark clothes, light clothes and a reflective vest: FizziQ makes retroreflection measurable.

Learning objectives

- Measure the light reflected by different clothing materials using the smartphone light sensor
- Compare the reflective properties of dark clothing, light clothing, and retroreflective safety vests
- Understand the difference between diffuse reflection, specular reflection, and retroreflection
- Build a quantitative argument for wearing high-visibility clothing at night
- Connect the measurement to road safety and the physics of light interaction with materials

Instruments and sensors

Light meter (lux meter) · Ambient light sensor

Materials

- Smartphone or tablet with the FizziQ app (light sensor / lux meter mode)
- A flashlight
- A vest with retro-reflective strips
- A light-colored piece of clothing
- A dark garment
- A space that can be darkened
- Note: the protocol remains adaptable to any comparable illuminance measurement tool.

Protocol

1. Set up the experiment in a room that can be darkened completely. You will need total darkness to measure reflected light accurately.
2. Gather three clothing items: a dark garment (black or dark blue), a light garment (white or yellow), and a safety vest with retroreflective strips.
3. Hang or hold each garment at the same position, about 2 meters from the flashlight position.
4. Open FizziQ on the measuring smartphone and select the Light Sensor (Lux) measurement.
5. Turn off all room lights. Position the flashlight next to the FizziQ smartphone (both pointing toward the garment). This simulates a car headlight and driver's eyes being close together.
6. Turn on the flashlight. Record the light sensor reading for the dark garment. Wait 5 seconds for stabilization and take 3 readings.
7. Replace with the light garment at the same position. Record 3 readings.
8. Replace with the safety vest, ensuring the retroreflective strips face the flashlight. Record 3 readings.
9. Calculate the average lux value for each material.
10. Compare the three values. The safety vest should return dramatically more light than either clothing option.
11. Calculate the ratio of reflected light: safety vest / dark clothing and safety vest / light clothing.
12. Discuss: at what distance would each clothing type become invisible to a driver? What are the implications for pedestrian safety?

Expected results

In a darkened room at 2 meters, the dark garment typically reflects 0.5-2 lux back toward the sensor, the light garment reflects 5-15 lux, and the retroreflective safety vest reflects 50-500 lux (depending on the quality of the strips and the alignment with the flashlight). The ratio of retroreflective to dark clothing can be 50:1 or higher, dramatically illustrating why safety vests are so effective. The retroreflective signal drops rapidly if the sensor is moved away from the flashlight axis, confirming that the strips specifically return light toward the source. Students should observe that the retroreflective effect is much stronger when the flashlight and sensor are close together, simulating the geometry of a car headlight and driver's eyes.

Questions

- What is the physical difference between diffuse reflection, specular reflection, and retroreflection?
- Why are retroreflective strips so much more visible to drivers than ordinary white clothing?
- How do the tiny glass beads or prisms in retroreflective materials work?
- At what distance can a driver see a pedestrian wearing dark clothing versus a safety vest?
- Why is the retroreflective effect strongest when the observer is near the light source?
- What other applications use retroreflective materials (besides safety vests)?

Going further

- Measure reflected light at different distances (1 m, 2 m, 3 m, 5 m) and compare how the signal decreases for each material
- Test different colors of clothing (red, blue, green, yellow, white, black) and rank them by reflectivity
- Compare the retroreflective strips on different brands of safety vests
- Investigate whether wet retroreflective strips are less effective than dry ones
- Design a visibility test by placing the clothing items at increasing distances and finding the maximum detection distance for each