PhyzLabSpringboard: Why the Sky is Blue

• Demo and Lab Apparatus •

__2 resonant tuning forks __optics tank (without insert) __access to scattering agent
__mini maglite (incandescent or LED) (or equivalent bright light source)

• Discussion •

INITIAL IDEAS

1.Why is the sky blue? What are some of the ideas you've heard? What might people say if you were to take a survey of the general public?

Reflection of the ocean.
Blue light is scattered in the atmosphere.

2.Can you think of any problems with these ideas?

Why is the sky blue in Kansas?
Why is blue scattered better than other colors?

BLUE SKY INGREDIENTS

3.What is "the sky" and what is it made of?

The sky is the earth's atmosphere and is composed of nitrogen (78%), oxygen (19%), and other gases (3%).

4.Which of those materials—if any—are blue?

5.What color is the sky at night? Black (the absence of color).

6.What is different during the day? The sun is out.

7.The daytime sky on a clear day appears to be blue. On the moon, the sky is on the illuminated side is black. What are the essential "ingredients" for a blue sky?

Air and sunshine.

TUNING FORKS LESSON

8. To understand how these "ingredients" interact to create a blue sky, consider the following demonstration. A tuning fork is struck.

a. What happens when the tuning fork is struck? Why?

The tuning fork emits sound waves of a single frequency.

b. How can a tuning fork be silenced?

Stop the vibration—rest a hand atop the tines, for example.

c. A second tuning fork is added to the arrangement. What is the surprising observation this time?

When the first fork is struck then silenced, the sound of the fork continues. When the second fork—which was never struck—is silenced, the sound stops!

d. What is the name and explanation of this effect?

Scattering. The sound from the first fork causes the second fork to vibrate. This works as long as the second fork has the same resonant frequency as the first one.

e. Imagine a huge collection of tuning forks with a wide range of different notes. Suppose they were all struck. Now imagine a second collection of tuning forks—each having the same note—near the first collection. Would any of the the forks in the second collection be activated by the sound coming from the first collection? Explain.

Yes, since some of the forks in the first collection will match the forks in the second collection.

FROM THE SUN TO THE SKY

9. a. Does the sun emit one frequency of electromagnetic radiation or many frequencies? Describe.

Many frequencies—from radio through gamma. Peak radiant energy is near the yellow-green part of the visible spectrum.

b. Do atmospheric molecules resonate at all frequencies or do they "prefer" a particular area of the electromagnetic spectrum? Describe.

Atmospheric molecules resonate at UV frequencies. As incoming frequencies get lower, the amount of scattering gets smaller.

c. How does the lesson of the tuning forks apply to the scattering of light in the atmosphere?

The sun is like a giant collection of "optical tuning forks." The atmosphere is like a collection of equal-sized "optical tuning forks." Some waves from the sun activate atmospheric molecules; those waves are scattered in the atmosphere.

10.a. Are our eyes equally sensitive to all frequencies of visible light? If not, what color(s) do our eyes “prefer?”

No: our eyes are most sensitive in the yellow-green part of the spectrum.

b. What are some examples of objects colored to take advantage of this sensitivity?

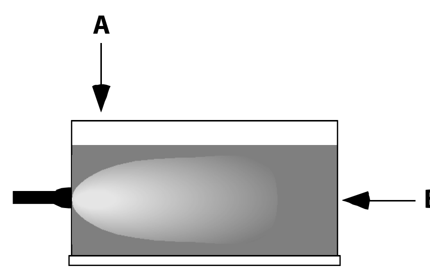
Tennis balls, fire trucks, etc.

11.a. Our eyes are more sensitive to green than they are to blue. Why is the sky not green?

Green is not scattered as well as blue.

b. Violet light is scattered more than blue light is. Why is the sky not violet?

Our eyes are not as sensitive to violet as they are to blue.



ONE SKY TWO SKY RED SKY BLUE SKY

• **Procedure** •

1. Fill the optics tank (with no back insert) with water.

2. Add and disperse the scattering agent.

3. Activate the light and shine it through the tank as shown in the diagram.

4. Observe the illuminated tank from the top (see “A" in the diagram).. Describe the coloration—if any—of the water near to the maglite.

Bluish

5. Observe the illuminated tank from the far end (see “B" in the diagram). Describe the coloration—if any—of the illuminated water.

Orangish

• Questions •

Consider the diagram of the earth as seen from far above the North Pole. The earth rotates counterclockwise from this perspective. (The thickness of the atmosphere is highly exaggerated.)

1. What time of day is it at each location: A, B, and C?

A: sunrise
B: midday
C: sunset

2. What is the color of the sky at each location: A, B, and C?

A: red-orange
B: blue
C: red-orange

3. Explain the difference in color making reference to your optics tank observations above.

When sunlight passes through a thinner layer of atmosphere, the blue gets scattered throughout the sky. When it passes through a thicker layer of atmosphere, the blue has been scattered out; only the oranges and reds remain.