Name: _____ Date: _____

INVESTIGATION 22A

Light and Color

1 Sources of light

a. Compare the light from a light bulb with the light from the same bulb when seen in a mirror. In both cases, describe the path of the light from the source to your eyes.

b. Look at your clothes. Does the light reaching your eye from your clothes originate in your clothes? Or does the light originate somewhere else?

c. Turn off all the lights, and shade the windows so it is completely dark. Can you see your clothes in the dark? What does this experiment tell you about whether your clothes give off their own light or reflect light from somewhere else?

d. Turn on a television or computer screen in a dark room. Can you see the TV or computer screen in the dark? What does this experiment tell you about whether the TV or computer screen give off their own light or reflect light from somewhere else?

2 Making colors

There are no questions to answer in part 2.

3 Thinking about what you observed

Record your answers to questions a-d in table 1.

a. What color do you see when you mix red and green light?

b. What color do you see when you mix red and blue light?

c. What color do you see when you mix blue and green light?

d. What color is produced when all three colors of light are equally mixed?

Table 1: Mixing primary colors of light

LED color combination	Color you see
Red + Green	
Green + Blue	
Blue + Red	
Red + Green + Blue	

e. Research and explain the following terms from the diagram below: cone cells, rod cells, retina.

f. Research and explain how the eye sees white light in terms of the photoreceptors in the eye.

4 The subtractive color model (CMYK)

There are no questions to answer in part 4.

Name: _____ Date: _____

INVESTIGATION 22A

5 Thinking about what you observed

a. Explain how the mixture of magenta and cyan makes its color when seen in white light.

b. Explain how the mixture of cyan and yellow makes its color when seen in white light.

c. Explain how the mixture of yellow and magenta makes its color when seen in white light.

d. Why don't the mixed colors produce full red, green, or blue?

e. What color would appear if you looked at a mixture of magenta and cyan under a lamp that only made blue light?

f. Research how printers make colors. Do they use red, green, and blue (RGB) or cyan, magenta, yellow, and black (CMYK)? Explain why printed pictures need to use one or the other.

g. Research how computer monitors and televisions make colors. Do they use red, green, and blue (RGB) or cyan, magenta, yellow, and black (CMYK)? Explain why TV's and computer screens need to use one or the other.

Name: _____ Date: _____

INVESTIGATION 22B

Reflection and Refraction

1 Observing the law of reflection

There are no questions to answer in part 1.

2 Thinking about what you observed

a. Draw a ray diagram showing the surface of the mirror and the light rays before and after the mirror.

b. Which is the incident ray? Label it on your ray diagram.

c. Which is the reflected ray? Label it on your ray diagram.

3 The law of reflection

a. For each ray diagram, draw a line perpendicular to the mirror surface at the point where the rays hit. This line is called the *normal line*.

b. Use a protractor to measure the angle between the normal and the incident and reflected rays.

c. Write down your own statement of the law of reflection, describing the relationship between the angles you measured.

Table 1: Angles of incidence and reflection

	Diagram #1	Diagram #2	Diagram #3	Diagram #4
Angle of incidence				
Angle of reflection				

4 Light rays going through a prism

There are no questions to answer in part 4.

Name: _____ Date: _____

INVESTIGATION 22B

5 Sketching what you observed

a. Draw at least one ray diagram showing a laser beam that is refracted passing through the prism. The ***refracted ray*** is the ray that comes out of the prism.

b. Draw a ray diagram showing a laser beam that is reflected passing through the prism.

c. Draw a ray diagram showing a laser beam that is both refracted and reflected passing through the prism.

Name: _____ Date: _____

INVESTIGATION 22B

6 Seeing reflection and refraction at the same time

There are no questions to answer in part 6.

7 Thinking about what you observed

a. Draw a diagram showing the path of the light when you see the letter A.

b. Draw a diagram showing the path of the light when you see the letter B.

c. Is the image in the prism always reflected or refracted or can there be both reflection and refraction at the same time?

Name: _____ Date: _____

INVESTIGATION 22B

8 The angle of refraction

There are no questions to answer in part 8.

9 Thinking about what you observed

a. Draw the normal line to the surface at the points where the light ray enters and leaves the cup. A round cup is convenient because the normal line points toward the center of the circle.

b. When the light is going from air into water does the ray bend toward or away from the normal?

c. When the light is going from water back into air does the ray bend toward or away from the normal?

Name: _____ Date: _____

INVESTIGATION 23A

Optics

1 Making an image with a lens

Table 1: Focal lengths of lenses

	Focal length (mm)
White Lens	
Black lens	

a. Was the image created by a single lens smaller or larger than the object?

b. Was the image right side up or was it inverted?

2 Projecting an image with a lens

There are no questions to answer in part 2.

3 Thinking about what you observed

a. Describe the characteristics of the image formed by the lens. Characteristics include whether the image right-side-up, inverted, larger, or smaller.

b. Discuss with your class why blocking part of the lens makes the image dimmer, even though you still see the entire image.

Name: _____ Date: _____

INVESTIGATION 23A

4 Finding the magnification of a lens

Table 2: Magnification data for a single lens

Distance to paper (cm)	# of squares on the graph paper (unmagnified squares)	# of squares in the lens (magnified squares)	Magnification

5 Thinking about what you observed

a. Is the image in a magnifying glass inverted or upright?

b. At what distances will the lens act like a magnifying glass? What happens when the object is more than a focal length away?

c. Describe something that looks completely different under a magnifying glass than when seen with the un-aided eye.

Name: _____ Date: _____

INVESTIGATION 23B

Optics and Images

1 The image in a mirror

There are no questions to answer in part 1.

2 Thinking about what you observed

a. Relative to the mirror surface, where did the image of the arrow appear in the mirror? How deep into the mirror was the image?

b. Remove the mirror and use the ruler to extend the two reflected rays beyond where the mirror was. They should meet in a point on the other side of the line, like in the example on the right. What is the significance of the point where the reflected rays meet?

3 Refracting light through a lens

There are no questions to answer in part 3.

4 Thinking about what you observed

a. Describe the path of the laser beam as it travels along the axis and through the lens.

b. What is the focal point of a lens? Mark the focal point on the ray diagram you just drew.

c. What is the focal length of a lens? Measure the focal length of the flat glass lens from the ray diagram.

d. Look back at your results from part 1 of Investigation 23A. Where does the image of a distant object form relative to the lens?

Name: _____ Date: _____

INVESTIGATION 24A

The Frequency and Wavelength of Light

1 Breaking light apart

Table 1: Examining light sources

Red LED	Green LED	Blue LED
White LED		**Red laser spot**

2 Thinking about what you observed

a. Describe the similarities and differences you observed in the spectra from the red, blue, and green LEDs.

b. Describe what you saw looking at the white LED. Compare the spectrum from the white LED with the spectra from red, green, and blue.

c. Describe the spectrum you saw looking through the diffraction grating glasses at the spot made by the red laser on the screen. How is the spectrum of the red laser different from the spectrum of the red LED?

d. Based on your observations, explain how the colored filters transform the white light of the LEDs inside the lamps into red, green, and blue.

Name: _____ Date: _____

INVESTIGATION 24A

3 The spectrometer

Table 2: Spectrometer observations

Apparent color	Observed range of wavelengths	Appearance of lines?

4 Thinking about what you observed

a. What range of wavelengths is visible light? Express your answer in meters.

b. Research the thickness of an average human hair. How many wavelengths of red laser light fit in the width of a hair?

c. Give a brief explanation of the colored lines in the spectrum of the fluorescent bulb.

Name: _____ Date: _____

INVESTIGATION 24B

Waves and Photons

1 Polarization

There are no questions to answer in part 1.

2 Thinking about what you observed

a. Describe how the term *polarization* applies to the two different kinds of waves you made.

b. How many polarizations are there for a water wave like the one you made in Investigation 20A?

c. Suppose you shake the spring at an angle halfway between vertical and horizontal. This makes the wave also oscillate at the same angle. Is this angle a totally different kind of polarization or can it be represented as a combination of the other two waves you made before? You should discuss this question with your class because the answer is not simple.

3 The polarization of light

There are no questions to answer in part 3.

4 Thinking about what you observed

a. What is the difference between polarized and unpolarized light?

b. Why did the image appear the same when viewed through one polarizer, even when the polarizer was rotated to any angle?

c. Explain why rotating a second polarizer on top of the first polarizer changes the amount of light you see coming through. You may use the diagram for reference.

d. Explain how polarization allows two waves to be different *even if they have the same frequency, amplitude, phase, and wavelength*.

5 Reflecting on what you did

There are no questions to answer in part 5.

6 Why polarizers make good sunglasses

There are no questions to answer in part 6.

7 Thinking about what you observed

a. Is there an orientation of the polarizer that allows you to see through the glare? If so, what is it?

b. What does this experiment tell you about the light that is reflected from the surface of the water compared to other light you see?

Name: _____ Date: _____

INVESTIGATION 24B

8 Glow-in-the-dark plastic

There are no questions to answer in part 8.

9 The effect of different colors

There are no questions to answer in part 9.

10 Thinking about what you observed

In answering these questions, think in terms of light and energy.

a. Why didn't the plastic that was covered by your hand glow? Explain in 1-2 sentences.

b. What is the energy of green light compared to red and blue?

c. Propose an explanation for why the red and blue lights had different effects on the glow-in-the-dark plastic.

d. Holding the LED lamp closer to the surface makes the light on the surface brighter. Brighter light means more energy. The red light did not make a glow even when it was close, while the blue light made a glow even 10 cm away. How does the photon theory of light explain this observation? This is a class discussion question and the answer took many years to deduce.