STUDENT LAB SHEETS

Lab sheets are available for each lesson in the 5E format for use at the teacher's discretion.

The lesson is labeled in the top right corner of the first sheet. Ex: EXPLORE

Suggestions include:

- completion by students and inserted into science journal
- concepts, vocabulary, drawings, and information written into science journal
- use part or all of the lab sheets as content, time, and materials allow or are desired

ENGAGE

What Do You See?

KEY VOCABULARY complete as you go

emission of light: generating and putting out light

transmission of light: movement of light through a medium

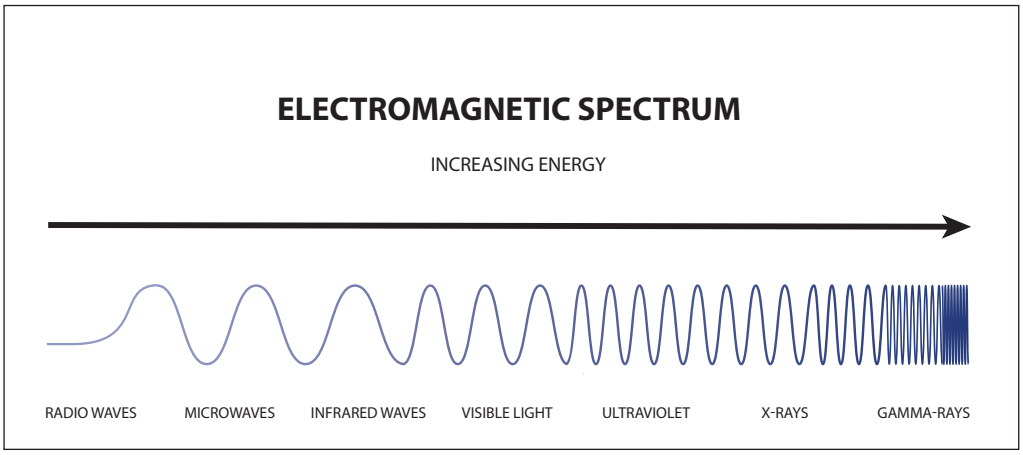
absorption of light: taking in and holding light

Light is **emitted** from a source. The white light comes in contact with objects. Some objects **transmit** the light or let it shine right through, such as clear plastic or the glasses you put on. Some objects take in the light and change the energy into heat. This is known as **absorption**. Other objects bounce the light right off a surface. We call this reflection. Many objects do a bit of all of these. When we look at objects we see what color or colors are reflected to our eyes. Since all colors are contained in white light, objects that appear white to our eyes bounce back all the colors together and we see white.

When we look at a ripe banana, all of the colors shine on the banana. The banana absorbs all the colors (ROYGBIV) except yellow. Yellow reflects back to our eyes and we see a yellow banana. **Using this logic, explain to a partner why plants are green.**
Plants absorb all colors except for green and reflect green back.

How Does Light Travel?

The sun emits energy in the form of waves. These waves travel through space at the speed of light and make up the electromagnetic spectrum. Each type of wave has a different wavelength (the distance between each wave). As the distance between the waves gets smaller, the energy of the wave increases because there are more waves in a shorter amount of time. Within these different wavelengths is a special group of waves called visible light. This light is what allows us to see all the objects around us. The other waves in the electromagnetic spectrum are invisible to our eyes but are able to be detected using specialized equipment.



1. Which waves have the most energy?
   Gamma rays

2. Where is visible light located on the electromagnetic spectrum above?
   Middle
   What does this tell us about its energy?
   Example: More energy than microwave, but less energy than x-rays.

3. What other waves have you heard of on the electromagnetic spectrum? List them below and then share out loud with a partner or the class what you know about each.

TEACHER DEMONSTRATION RAINBOW OF LIGHT

Based on your observations, answer the following questions.

1. What is visible light?

Visible light is a combination of red, orange, yellow, green, blue, indigo and violet that we see combined.

2. List three objects that produce and emit light?

Some examples are the sun, light bulbs, tv screens, computer screens. Basically anything that generates and puts out it's own light.
Note: Not the moon, it is reflected light.

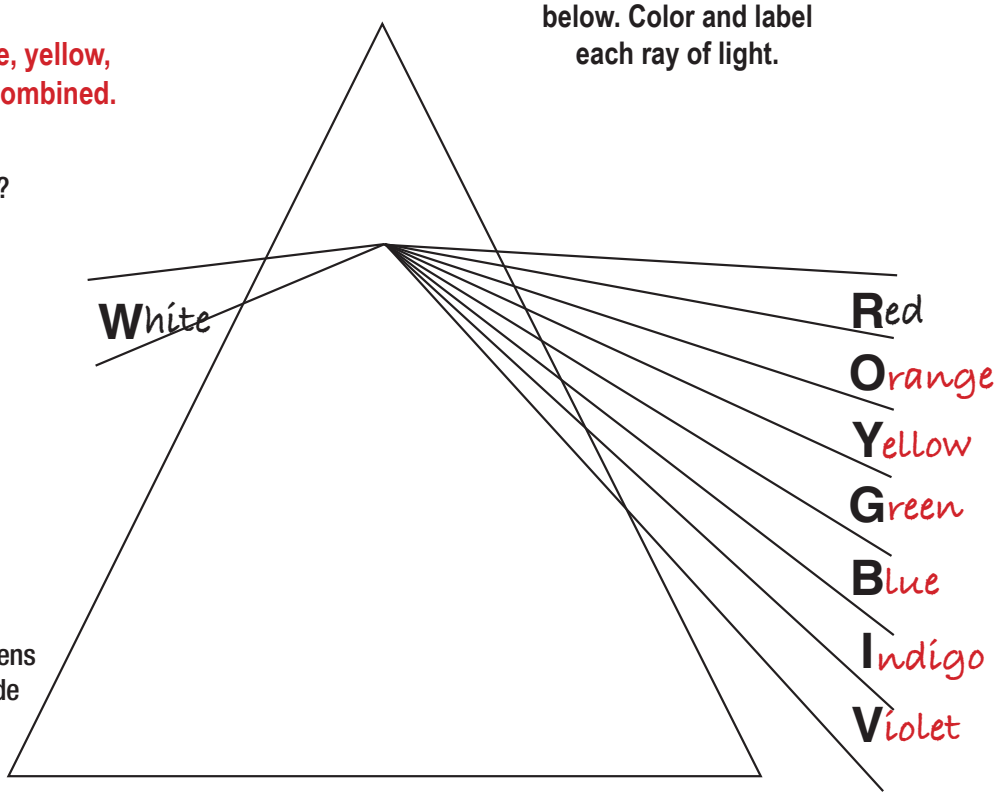
3. What color does light appear to be?

White

4. We call natural light "white light". What happens to the white light as it shines out the other side of the prism?

Shows ROYGBIV

Complete the diagram below. Color and label each ray of light.



STUDENT ACTIVITY - 1

RAINBOW GLASSES

Using the rainbow glasses provided in the kit, look into the lights around your classroom.

1. Pick your favorite light pattern. In the box, illustrate and describe what patterns and colors you see.

2. The glasses tell you about the lights that shine around you. How is it different than looking just with your eyes?

The glasses show the ROYGBIV, but without them on you just see the white light.

DRAW AND EXPLAIN HERE:

STUDENT ACTIVITY - 2 COMPARISON OF COLORS, REFLECTION, AND ABSORPTION

Place the pieces of construction paper on the desk or table in front of you. With the lights off, shine the flashlight on the center of each color and rank the colored paper from brightest (1) to the least bright or dimmest (4).

PAPER COLOR	WAS MORE LIGHT ABSORBED OR MORE LIGHT REFLECTED?	RANK
blue	More light seems to be absorbed, less reflected, dim blue.	
red	More light seems to be absorbed, less reflected, dim red.	
yellow	Less light seems to be absorbed, more reflected, bright.	
black	Almost all the light is absorbed, very little reflected, dim.	

1. Does absorption or reflection make an object appear brighter? Explain your thoughts.

Reflection. If the darker colors are absorbed and the lighter colors are reflected the brighter the objects will appear.

2. If objects that absorb light convert the light energy to heat energy, which color object would absorb the most light and increase in temperature most easily: black or yellow? Explain your answer.

Black would absorb the most light energy and then convert it to heat energy, becoming hotter than a similar but yellow object.

3. In conclusion, explain how reflection and absorption determine which colors we see and how bright a color appears to our eyes. You may use an example to help explain your answer.

Colors that are absorbed are not visible to our eyes, but those reflected are. If only one color, such as blue is reflected, then the object will appear blue while a combination of colors reflected such as blue and green might appear aqua blue, a combination of colors.

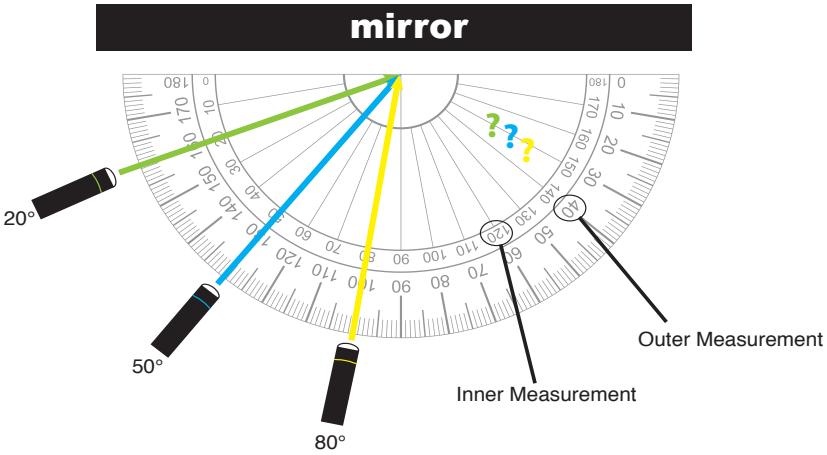
How does light travel?

Light travels on waves in a straight line at the speed of light, 300,000 kilometers per second, through space. As light travels or is transmitted or moves through other materials the light is slowed down. Sometimes the light bends, or is refracted. Other times it is reflected, absorbed or diffused. Some objects are better at reflecting light, others are better at absorbing light. Let's explore some materials and see where the light goes!

STUDENT ACTIVITY - 1

ANGLE OF REFLECTION

Let's see if we can figure out what the angle of reflection is by doing a test. We will be shining the laser at an angle of 20°, 50°, and 80°, where do you think the light will go? Fill in below. With the protractor sitting against a standing mirror, shine the laser down the left side using the inner measurements. While one team member holds the laser steady have another team member measure the angle of the reflected laser on the right using the outer angles. **Draw lines on the diagram to the right to show where your light travels each time. Round to the nearest 10 degrees. Also, fill in below.**



	HYPOTHESIS	OBSERVED
20°		
50°		
80°		

CONCLUSION:

1. Is the angle that light hits and reflects the same or different?

The same, 20 degrees in equals 20 degrees out.

2. If you were to shine your headlights on a street sign that is off to your right, where do you think the light would go?

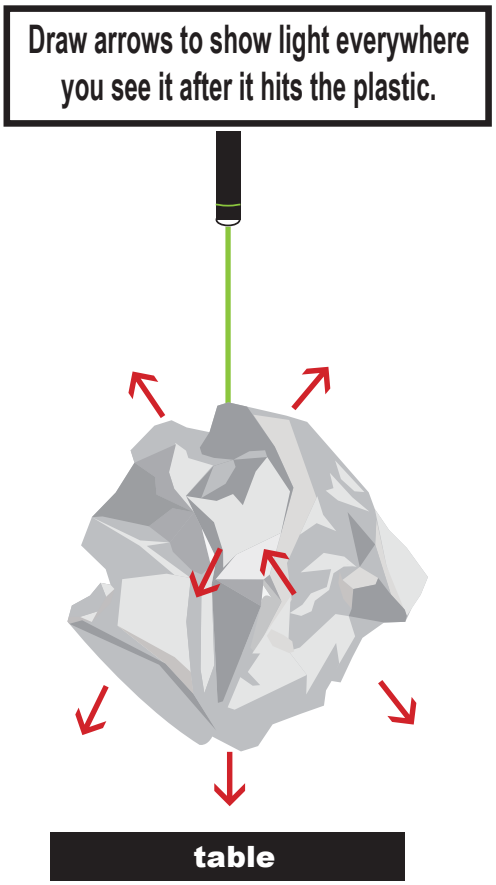
Further off to the right at the same angle it came in from.

3. Would it be easy or difficult to see that sign at night? **Explain.**

You would not see the reflected light. It would reflect out of sight.

STUDENT ACTIVITY - 2 DIFFUSION

Take a piece of clear plastic wrap. Wad it up into a ball so that it stays together, but not too tight. Hold it a few inches above the surface of the table. Shine the laser pointer into the top from about 2-3 inces above. Answer questions about where the light goes below:



1. Is any light reflected off the plastic?

   Yes, some of the light reflects off of the plastic.

2. Is any of the light absorbed?

   Some of the light is absorbed and trapped inside the ball of plastic.

3. Is any light transmitted through the plastic to the table?

   Yes, there is light that passes through to the table.

4. This investigation demonstrates DIFFUSION. Based on your observations, how would you define diffusion?

   Diffusion is the scattering of light in many different directions.

STUDENT ACTIVITY - 3 REFRACTION

Using a 300ml beaker or clear drinking glasses, fill it 2/3 with water. First place a straw in the middle of the glass.

Looking beside the glass from the front, draw what you see in the water below. Repeat for number 2, placing the straw closer to the edge of the glass.

Describe what you see in each glass.

1. Glass #1:

   The bottom of the straw appears as a separated line from the straw above the waterline and larger under water.

2. Glass #2:

   The bottom of the straw appears as a separated line from the straw above the water line and larger under the water. There is more of a gap between the two lines.

3. What do both paths have in common?

   Both lines are separated and larger under the waterline.

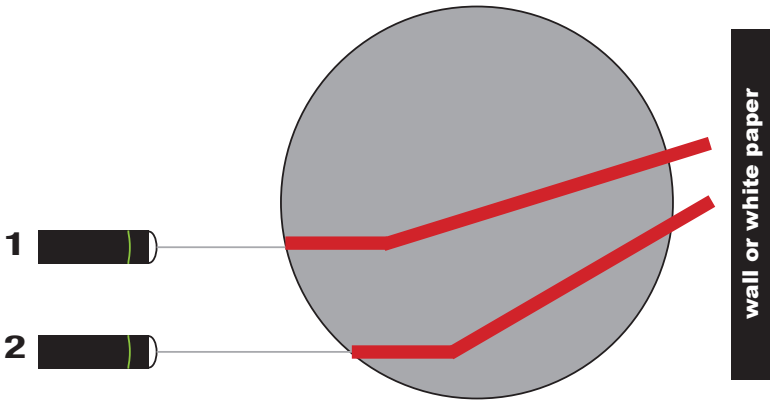
4. Which path shows the greatest difference from the actual straw? **Explain.**

   The bottom straw in glass number 2 appears further separated from the top straw and the straw in glass number 2 appears larger.

STUDENT ACTIVITY - 3 REFRACTION CONTINUED

Shine a laser light through the liquid and look through the top of the glass. First shine the light through the middle and then through closer to the side.

Draw the path of the laser light for each below.



Describe what you see in each glass above.

1. Laser #1:

There is refraction, the light bends through the middle.

2. Laser #2:

There is refraction, the light bends more through the middle.

3. What do both paths have in common?

Both show refraction of the laser light as it passes through the water.

4. Which shows the greatest difference from the entry light? **Explain.**

The path that begins closer to the outside of the beaker (#2) has a greater amount of refraction than the one in the middle (#1).

REFRACTION refers to the bending of light. Based on your above observations, answer the following questions.

1. Did light from the straw and the laser bend more or less when closer to the outside curved surface of the glass?

The laser bends more when the straw and the laser are closer to the outside. The water and the glass were at a more curved angle and thus bent the light with a greater angle.

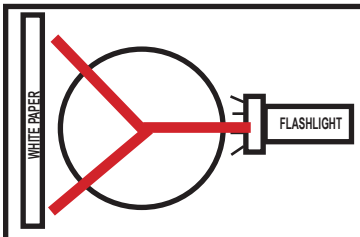
2. If water bends light, where or how might what a driver sees change in the rain or snow?

In the rain or snow, the drops or flakes will also refract and diffuse light as it passes through the precipitation.

EXPLAIN

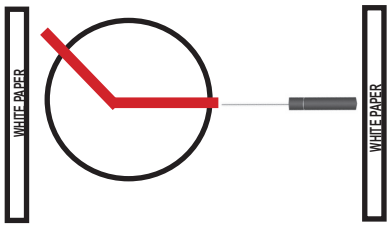
Can we change what we see?

TEACHER DEMONSTRATION LIGHT THROUGH A GLASS SPHERE



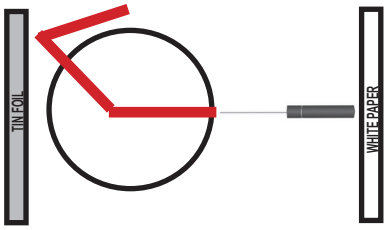
1. Where does the light from the flashlight go as it is transmitted through the glass ball? Illustrate and describe.

The light is transferred through the glass sphere. The light refracts as it passes through the sphere. The light is also diffused onto the white paper in front of it.



2. Where does the light from the laser go as it is transmitted through the glass ball? Illustrate and describe.

The light is transferred through the glass sphere. The light refracts as it passes through the sphere. The light also shines on the white paper in front of it; less diffusion.



3. When metal is placed behind the glass ball, does this change what you see from the laser pointer? Illustrate and describe.

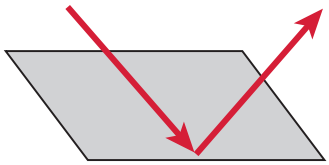
The light is transferred through the glass sphere. The light refracts as it passes through the sphere. The light shining on the tin foil is reflected off at the same angle it strikes at.

What happens when the teacher wraps the foil on the back of the glass sphere?

With the tin foil wrapped around the sphere, the light from the laser is refracted and reflected back to the light source (onto the white paper). The wrapped tin foil helps direct and control where the light goes. It retroreflects.

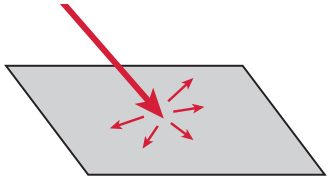
When people drive their vehicles they need to be able to see signs that are high in the air and on the side of the road. For this to happen we need to combine reflection, refraction and diffusion so that the light from the headlights returns to the vehicle.

Briefly describe what the light is doing in each picture.



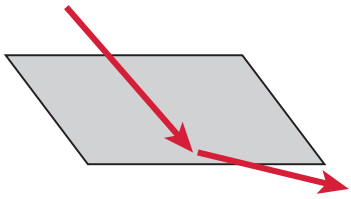
REFLECTION

The light bounces off the surface at the same but opposite angle of entrance.



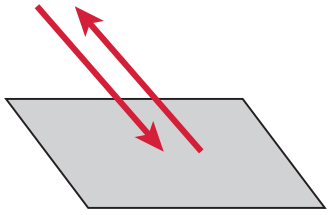
DIFFUSION

Light is transferred through and reflected off of the material and scatters.



REFRACTION

As the light is transferred through the item, it bends.



RETROREFLECTION

Light is reflected off the surface and back to the source using reflection and refraction.

RETROREFLECTION combines reflection with refraction and some diffusion to help drivers better see road signs.
Based on your observations, describe how retroreflection works.

Retroreflection is when light is reflected and refracted in a way that the light is returned towards the source.

STUDENT ACTIVITY - 1 DOES COLOR MATTER?

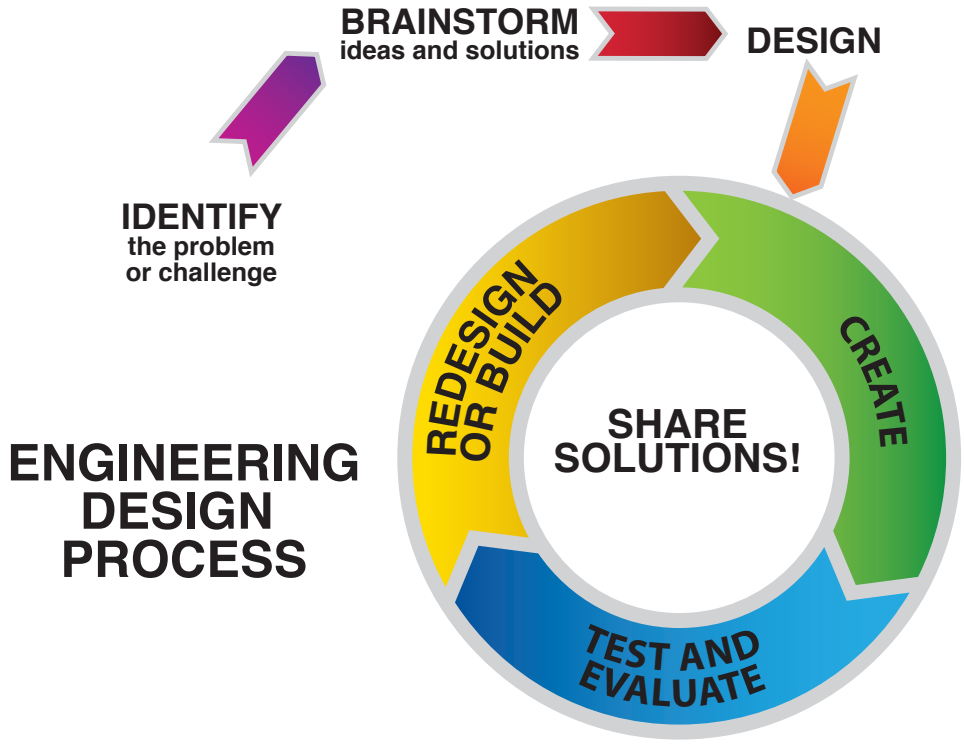
Place the five various colored marbles on a white or light colored surface. Holding the flashlight in front of your chin, shine the light at each marble and record what you see. Describe how the light retroreflected with each color and rate them 1-5, brightest=1, dimmest=5.

COLOR:	COLOR 1:	COLOR 2:	COLOR 3:	COLOR 4:
CLEAR				
RANK	RANK	RANK	RANK	RANK
1	Light colors rank 2-3 while darker colors will rank 4-5.			

ELABORATE

Can we control what we see?

Engineering is about developing new solutions to problems and challenges in our world. The Texas A&M Transportation Institute works every day towards solutions in all aspects of transportation. They conduct over 700 research projects each year on the land, sea and in the air.



ENGINEERING DESIGN PROCESS

The engineering design process is fluid. It does not have to begin or end at a particular point. One important aspect of the process is to share solutions along the way with others. Engineering is the design and building of new ideas.

TEAM CHALLENGE:

Design and build a directional sign to achieve maximum retroreflection to the driver with headlights at night.

MATERIALS:

12 marbles
clay or play-doh
rulers
foil
8"x 11" manila folder
construction paper
scissors
glue
clear tape

KEY VOCABULARY

As a class, define each of the following words and determine how they are important components of engineering.

effective: When the product actually does what it was intended to do.

criteria: The specifications to which a product is designed. What it needs to have and what it must do.

STUDENT ACTIVITY - 1 ENGINEERING DESIGN PROCESS CHALLENGE!

PART I: DEFINE THE PROBLEM OR CHALLENGE

With your team, state your challenge. What is it that you are trying to accomplish? Decide this as a group.

ONCE YOU HAVE DEFINED THE PROBLEM OR CHALLENGE AS A TEAM, YOU WILL WORK ALONE ON THE NEXT TWO STEPS!

BRAINSTORM: ALL ideas are good ideas at this stage. Here is where creativity is needed and no reasonable idea is bad or wrong. This part of the process helps us use what we know and combine it with imagination. Did you ever hear the saying, " two heads are better than one?" Well here EACH team member should come up with their own idea or ideas to share with the group. **Work independently and write down all your ideas here.**

Anything within reason and specific to the task at hand.

PART 2: DESIGN

INDIVIDUAL: Continue to work alone to complete your design. Now it is time to work through all of the pros and cons of each idea. Here you will design a sign that tells drivers to turn right. You can use pictures or words or both on your sign. Make sure your sign fulfills the criteria and uses only the materials allowed. This design is your very own idea that you will share with the group after completing your design and answering the first two questions below. Be creative.

YOUR PERSONAL IDEA FOR THE SIGN

For this section, students must be specific in their design.
Make sure they include colors, number of marbles, foil if needed, etc.

What do you like best about your personal idea? Why?

What do you have the most concern about your personal idea? Explain.

PART 3: TEAM DESIGN

With your team, design again. Combine each member's design into one so that you maximize your great ideas for a successful design that meets the criteria. Be very detailed in your drawing and label all items. While not every idea will be a part of the team sign, all ideas help generate solutions. Part of the engineering design process is working through ideas to find the best solutions to the problem. 3M Engineer Tim Hoopman said, "Be a risk taker. Let your failures be your education and your successes be your legacy."

TEAM SIGN DESIGN (everyone should have the same sign here)

For this section, students must be specific in their design.
Make sure they include colors for each part/material,
number and color of marbles, foil if needed, drawn to scale, etc.

MATERIALS LIST:

Be very specific, ex: 3 red marbles. Remember you can ONLY use materials from the original list.

CREATE: Make a sign using the team's best ideas.

TEST & EVALUATE: Test out your sign and evaluate the results. Record all positive and negative results.

REDESIGN: Redesign to solve any problems with your sign. Document some things you might change to the design. Did you consider varying the depth of marbles, adjusting the spacing between marbles, or changing what is behind each marble or marbles?

FINAL TEAM SIGN DESIGN

For this section, students must be specific in their design.
Make sure they include colors for each part/material,
number and color of marbles, foil if needed, drawn to scale, etc.

SHARE SUCCESS:

Share successful solutions with the class, not only the finished product, but the steps you took along the way.

What are some features that successful projects have in common?

Most likely they will have clear marbles with foil wrapped or in place behind the marble surrounded by a dark background for contrast. They will have a clear, easy to read, and understandable message.

What was the best retroreflective feature on your project? Why?

Should be the clear marbles, so long as they had a shiny backdrop or foil wrapped on backside of the marble.

What was the best retroreflective feature of another project? Why?

Contrast is another factor that contributes to a good sign, as well as clear message.

How could we combine all the team's best work for even better retroreflective results?

Here the class will choose a feature from each sign and combine them into one sign.

If you had more time, or other resources, how could you improve on your sign?

Here students will likely add features and techniques they learned from other groups.

Can we make good better?

EVALUATE

STUDENT ACTIVITY - 1 A CLOSER LOOK!

Using the pocket microscope, look at each piece of sign sheeting material more closely. **Describe and illustrate what you see for each.**

1

2

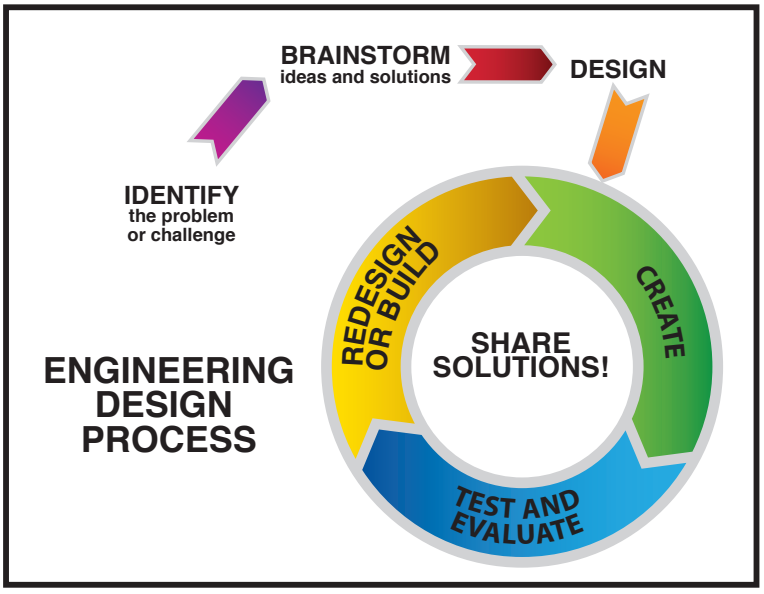
3

STUDENT ACTIVITY - 2 TEST ENGINEERING

As vehicles travel on our roads, some travel more slowly through neighborhoods or school crossings, while those traveling on the highways are going much faster. As you go faster, is it harder or easier to stop? Before answering, try this quick test. Walk around the classroom at a normal pace. Have someone in your group tell you when to stop. Have the others watch to see how quickly you are able to come to a complete stop. Next find a clear space that your teacher will allow you to run. Take off as fast as you can and again have someone in your group tell you when to stop and have the others observe. Discuss this quick investigation as a group to determine your results. Was it easier to stop quickly from a walk or a run? **Explain your reasoning**.

Now imagine vehicles on the roads, going slow and going fast. The important thing about traffic signs are that drivers are able to see and read them in time to follow them. Which of the reflective materials would allow drivers to read a sign sooner? In order to recommend one of these products you will need to use all of your prior investigative knowledge, as well as design an investigation to provide evidence that supports your recommendation with scientific proof.

Your group will act as test engineers on this activity. Test engineers design experiments they can test on products in order to assure they meet their requirements. You will be using the engineering design process to conduct your investigation. Rather than engineer a product, you will engineer a method of testing a product to verify its effectiveness to retroreflect.



IDENTIFY the problem or challenge. What is the problem you are working to solve or question you are trying to answer?

As a group they are trying to design an investigation that will best determine the retroreflective material that will best be seen by drivers at night from the greatest distance allowing drivers to most safely follow traffic signs.

BRAINSTORM ways to solve the problem. What are some methods you could use to test the materials. Remember all ideas are worth writing down and considering!

Here there will be a variety of ideas. Remind them that this is for a fast moving vehicle at night. Some may even realize that they can cut out patterns in the same dark paper and place it over the retroreflective material for "drivers" to identify. If so, they will need the same pattern, so that the amount of light shone onto the pattern is equal for each sample, possibly turned in different directions for the "driver" to say at what point they can identify the shape and possbily the direction. Examples would be an arrow, a letter in the alphabet pointed in a different direction for each of the three samples. Depending on the hallway, you may encourage them to have dimmer light (flashlight) to shine as the samples are all very retroreflective, even a small sample of the each of the retroreflective samples is very bright.

DESIGN your investigation. After discussing your ideas, narrow your investigation down to the investigation that will give you answers that will best help you solve your problem. Describe your investigation design in detail.

See above.

CREATE your investigation. Set everything up and prepare to investigate!

TEST AND EVALUATE! Conduct your investigation and record ALL observations, data, and more below. Draw any data charts, graphs and more you will be using to collect and analyze your data. Use a separate piece of paper as needed.