Can't Believe My Eyes! (Level 3)

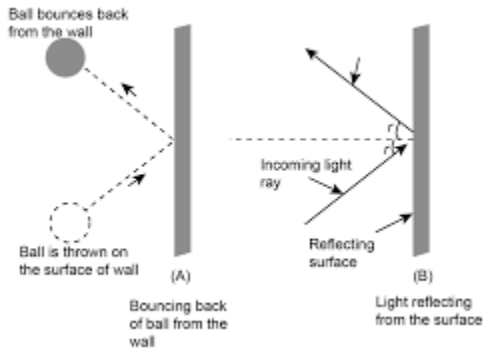
Description:	Learners will experiment with optical illusions to understand how our brains interpret what we see by applying concepts of reflection and refraction. They will then design their own optical illusion!
Leading question:	Can science help us design magical illusions?
Subjects covered:	Science, Literacy
Total time required:	40-60 mins a day for 5 days
Resources required:	A flashlight, a plane mirror, a spoon, colours, foil, a clear glass of water, paper, pencil
Learning outcomes:	By the end of this project, learners will be able to: Knowledge-Based Outcomes: 1. Distinguish between reflection and refraction. 2. Explain how rainbows are formed. 3. Draw a labelled diagram of a human eye and explain the role of each of its parts. 21st Century Skill Outcomes: 1. Think critically while making inferences from experiments. 2. Think creatively while making their own illusions and ambigrams. 3. Communicate effectively while presenting their final project.
Previous Learning	Basic understanding of reflection, how angles are measured

Day 1 -

Today, you will revise what reflection is and learn about diffused reflection!

Time	Activity and Description
5 minutes	**Ability to See** What makes it possible for us to see? (*our eyes, a source of light, the object that reflects light into our eyes)* What about the brain? Do you think it plays a role in us seeing things? How? ***Note**: Show learners the given image and ask them to explain how this optical challenge works. Then, ask them to observe their own faces on the inside and outside of a spoon.* What do you observe? Do these images accurately show how you look? Why? 

<table>
<tr><td></td><td>Our image looks different on different reflective surfaces because different surfaces reflect light differently! Let us explore how!</td></tr>
<tr><td>5 minutes</td><td>Reflection
What makes it possible for you to see your image on a mirror or a spoon?

Note: Bounce a ball off the wall in the same way that the light would reflect and learners can explain the concept of reflection by sharing the incident ray (the light ray hitting the mirror) and the reflected ray (the light coming back to our eyes).
 
</td></tr>
<tr><td>10 minutes</td><td>Reflection of Light by Different Surfaces
- What are the uses of mirrors in our lives?
- What are some other surfaces we can use as mirrors?
- What do you find interesting about mirrors?

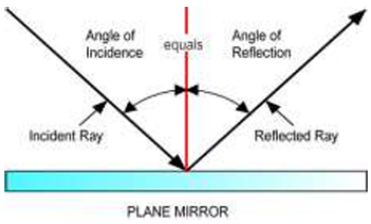
Note: Ask learners to draw the table shown below and list any other objects they think can be used as mirrors.
- Retain the information for mirrors in the table so that learners can identify what and how much detail to record in the table.
- If needed, give examples such as aluminium foil, a bowl of water, shiny spoons, utensils etc.

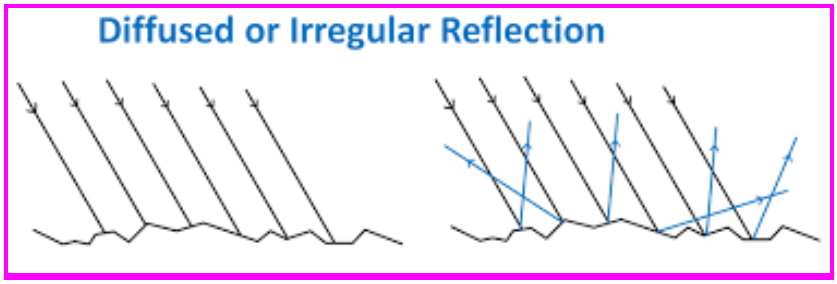
<table>
<tr><th>Characteristics of Surface</th><th>Absorb / Reflect</th><th>Observation</th></tr>
<tr><td>Surface: Mirror
Texture: Smooth
Colour: Clear
Finish: Polished</td><td>Reflects light</td><td>Does not heat up even though in the light</td></tr>
<tr><td>..</td><td></td><td></td></tr>
<tr><td>..</td><td></td><td></td></tr>
</table>

What is similar about surfaces that can be used as mirrors?

Often darker colours absorb light energy to become heat energy and do not reflect as easily. Smooth, polished and regular surfaces reflect more light energy

Tip: Ask learners to think about whether water absorbs or reflects light more or land.</td></tr>
</table>

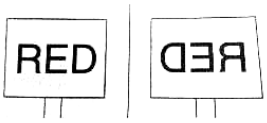
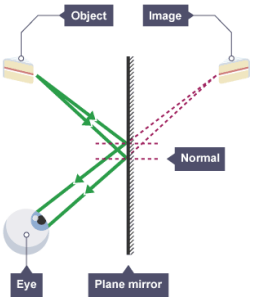
10 minutes	**First Law of Reflection** ***Note:*** *For this activity, ensure that learners have a mirror, a flashlight, and a piece of paper. Also, if possible, create a dark environment in the room.* Let us explore reflection in more detail by doing an activity. To do this; - Rest the mirror on a flat surface. Make sure that it does not move throughout the activity! - Shine the flashlight on the mirror. - Try to catch the reflected light on paper. Let us think about what you did to catch the reflected light! - How did you decide the position at which to hold the paper so as to catch the reflected light? - Did the reflected light fall on the paper when it was held at that position? If not, how did you move the paper to make sure that the reflected light fell on it? - What is the relationship between how you hold the flashlight and where the light goes? Before we discuss this, let us understand some scientific terms with regard to the reflection of light. ***Note:*** *Explain the terms listed below using the diagram shown alongside. As you explain, ask students to follow the instructions written inline:*  - ***Normal:*** *The imaginary line perpendicular to the surface of reflection.* *(<u>Instruction</u>: Place a ruler/ pencil perpendicular to the meeting point of the two rays on the mirror.)* - ***Angle of incidence:*** *The angle formed by a ray of light that travels toward a surface and the normal line.* *(<u>Instruction</u>: Trace the path of the light with a string connecting the flashlight to the mirror.)* - ***Angle of reflection:*** *The angle formed by a ray of light that travels away from the surface and the normal line.* *(<u>Instruction</u>: Trace the path of the light from the mirror to the paper.)* *Once done, explain to the students what the angle of incidence and reflection are, and ask them to find out if they could be related in any manner.* When a ray of light hits a reflective surface, the angle of incidence is always equal to the angle of reflection. This is the **first law of reflection**.
10 minutes	**Non-Plane Reflective Surfaces** Let us do an activity! - Take a piece of aluminium foil and fold it multiple times.

	- Now, use this as a mirror and carry out the same experiment as you did with a plane mirror and a flashlight. - Draw a similar table as you did for the previous experiment, and write your hypothesis, materials needed and method. What did you notice? Did the reflected light behave the same way as it did in the case of the plane mirror? ***Note**: Explain that because the surface of the foil was irregular, as opposed to that of a plane mirror, the light got reflected in multiple directions. Use the image below to describe this phenomenon as a **diffused or irregular reflection**.*  ***Note:** Allow students to look at the inside and the outside of a spoon again for this part of the discussion.* Now, let us think about the inside and the outside of a spoon. - In which case did your image appear smaller? Larger? - Was your image erect in both cases? - Do you think the reflection that takes place in a spoon is regular or irregular?  Image from the outer side of a spoon  Image from the inner side of a spoon The inner or concave surface of a spoon shows an inverted image while the outer or convex surface shows an erect image. This is because both these surfaces reflect light differently.
At home activities	**Make Your Own Magic Mirror** Have you seen magic mirrors in fairs? Can you make your own magic mirror by arranging them together? Students explore different reflective surfaces and make their own magic mirrors by arranging different objects together. (Eg: Tape a steel plate below a plane mirror and a curved vessel above it!) Students bring this to class the next day. 
Optional Literacy Activity	**Who Do You See?** Write about a person who means the most to you in your family or community. Connect their physical traits to who they are.

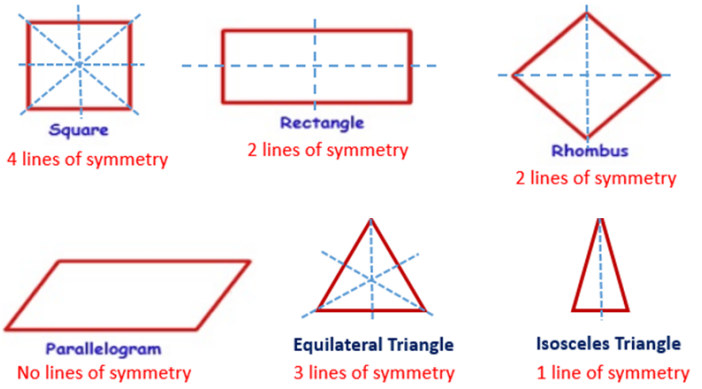
	(Eg: My mother's eyes sparkle with her joyful nature. My father's wrinkles on his forehead show how much he has worried for the well-being of our family.) Now, ask them what they notice about themselves in the mirror. Share what you wrote with them. Do you think ***how*** we see ourselves is more important than ***what*** we see?

Day 2

Today, you will learn about the lateral inversion of images in mirrors.

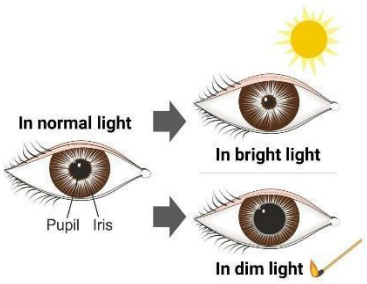
Time	Activity and Description
5 minutes	**Introduction** How did you make your magic mirror? How did you appear on it? So far, we have learned about reflection and how our images appear differently on different kinds of shiny surfaces. Today, we will explore more about images and the tricks of lateral inversions.
20 minutes	**Lateral Inversion** ***Note:*** *If there is only one learner studying this module, get them to bring a friend who can participate with them in this activity.* Today, we will try and pass a secret message to our friends using lateral inversions and multiple mirrors!  <u>Activity 1</u>: Pick a word that you would use to describe your friend. - Write it down on a piece of paper. - Hold it up against a mirror. - What do you observe? ***Note:*** *Challenge students to show the word on the mirror exactly how it is spelt by re-writing it on the paper.* How are the words different in the mirror? The left and right of a mirror image are reversed compared to the object. This phenomenon is called **lateral inversion**.  <u>Activity 2</u>: Now think, what if you had to use two different mirrors to pass this as a secret message to your friend? How would you do it? - Try keeping two mirrors perpendicular to each other and your secret message in the centre. - How and where would it reflect? - Is the word fully visible in both mirrors?

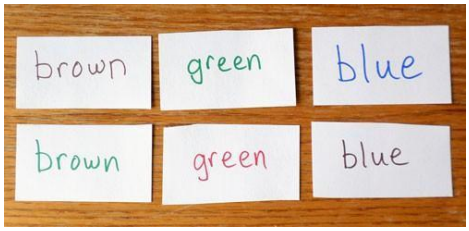
	- Is the word straight or laterally inversed? <u>Activity 3</u>: - Write a word on a piece of paper and stick it to the back of your friend's head. - Place a mirror behind their head. - How can you hold the second mirror to ensure that your partner can see the word getting reflected in the mirror behind their head? - Is the word straight or laterally inversed?
10 minutes	**Ambigrams** Just like how an object and an image are the same but laterally inverted, you can write words in a way so that you can read them both regularly and upside down. These are called **ambigrams**. ***Note:*** *Show learners some examples, such as the ones shown below:*  Let us now make an ambigram with our names! ***Note****: If needed, use an example, such as the one shown below, to explain to the learners how they can do this.* 
5 minutes	**Reflection** - What was the most effective way to pass on the message? Why? - What was the most confusing way? Why? - Did you enjoy making an ambigram of your name? - What role did your brain play in the sight during this process?
At-home activities	Talk to your family and community members about how mirrors are used in their cultural life – as part of traditions, marriage rituals, clothing (mirror work), and superstitious beliefs.
Optional Numeracy Activity	Students identify letters from the alphabet that have the same mirror image (Eg: A, W, X, etc.) ***Reflection symmetry in Math****: If there exists at least one line (called the mirror line/line of symmetry) that divides a figure into two halves such that one half is the mirror image of the other half.* 

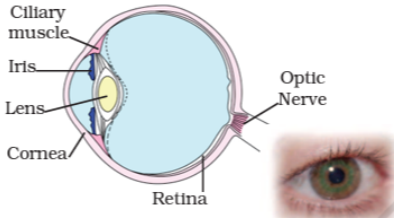
	Students draw the mirror line for the alphabets they identified (see figure for a few examples)  Challenge students to draw a shape that has a diagonal mirror line. Discuss: Which of these shapes DO NOT have a mirror line?

Day 3

Today, you will understand how your eye and brain work together to help you see and understand things!

Time	Activity and Description
10 minutes	**How Do Our Eyes Work?** Do you know what makes it possible for your eyes to help you see things? - Which parts of your eye do you think are responsible for your vision? - How do you think they work together to make you see objects? ***Note:*** *Explain the function of the eye as described below.* - The **iris** (the coloured part of the eye) regulates the amount of light that enters our eye by adjusting the size of the **pupil** (the black dot). - The **lens** in the eye focuses incoming light onto the retina, adjusting its shape through the action of the **ciliary muscle** to accommodate for near and far vision, allowing us to see objects clearly at varying distances.  If we already have lenses in our eyes, why do some people need additional lenses (spectacles)? The cornea is the outermost layer of the eye which plays a role in refraction. However, plays a significant role in focusing incoming light onto the retina. However, if the cornea's shape or curvature is abnormal or does not align with the length of the eye, it can cause vision problems which are corrected through glasses.

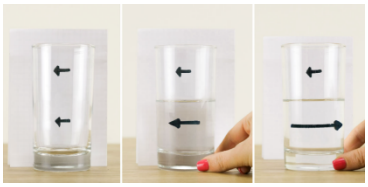
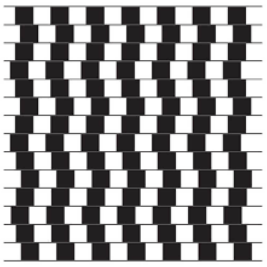
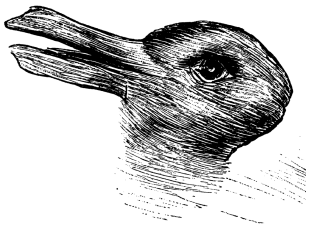
10 minutes	**Perception of Colour** **Note:** Ask learners to draw a star as shown in the figure on white paper. - Ask them to use green and yellow to colour it in. - Now, ask them to draw a black dot at the centre and stare at the dot for 20 seconds. - Finally, ask them to immediately look at the blank part of the paper.  What did you see when you suddenly looked at the blank part of the paper? Why did this happen? - There is a part of your eye called the **retina** that absorbs the light and sends messages to the brain, making it possible for you to see. - Other segments of the eye decode certain colours (these colours are paired, such as red and green; yellow and blue; black and white). - When you stare at an image like this for a while, you temporarily make an impression that stays on your retina. - However, when you stare at a certain colour for a while, your eye tends to bleach out the colour pair and trigger the other colour. - This is why you may see blue and red on the blank paper!
10 minutes	**The Interference Effect** ***Note:*** *If only one learner is participating in the module, get them to bring a friend to partner with in this activity.* Make 2 rows of words: - Row 1: Write the names of colours in the same colour. - Row 2: Write the names of colours in different colours.  Challenge your partner to **name the colour of the word** (not to read the word) as quickly as they can. - - For which row was it easier? - Can you guess why this happens? Our eye is connected to the brain through the **optic nerve**. - From the earliest years of school, reading is a task that people practice every day. - Eventually, we become so good at it that we read words just by looking at the word. - When we are asked to name the colour of the word instead of reading the word, somehow the automatic reading of the word interferes with naming the colour of the word. Our eyes work with our brain!

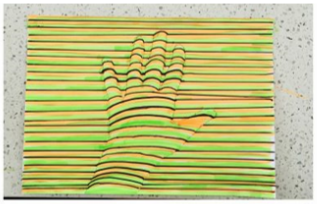
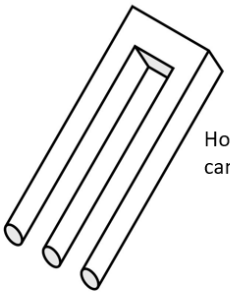
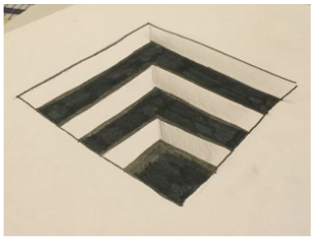
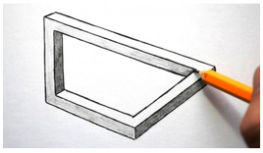
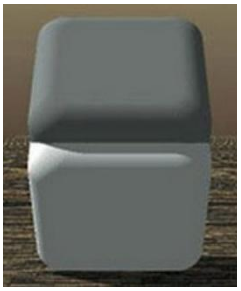
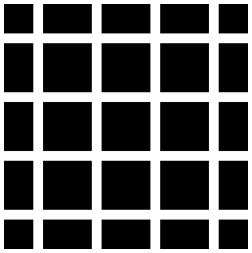
10 minutes	**Find Your Blind Spot!** Can you make an image in front of you disappear? - Take a piece of paper and make a small dot on one side and a cross on the other side 5 inches away from each other:  - Keep the paper at arm's length. Close your left eye. Look continuously at the cross. Move the sheet slowly towards you, keeping your eye on the cross. What do you find? - Now close your right eye. Look at the round mark now and repeat the activity. Does the cross disappear? Everyone has a spot in their retina where the optic nerve connects to the eye. This spot is called the blind spot. At this point, the retina cannot send messages to the brain when light falls on it. Do you see the effect of a blind spot when both your eyes are open? Try bringing a finger close to your eyes. *(Though it seems transparent, our brain is aware that it is our finger and fills the gaps for us!)*
At-home activities	- Draw the parts of a human eye in your notebook and explain its main function. - What are some local remedies to improve eyesight? Are they backed by science? 
Optional Numeracy Extension	Survey your neighborhood. Find out how many people use spectacles. - With permission, observe the thickness and type of glasses used. Are they the same? - The spectacles have a 'power' (a number, with either a negative or a positive sign). Find out what this number means. Find out what could be the reason for their weak eyesight. Present these responses as a bar graph.

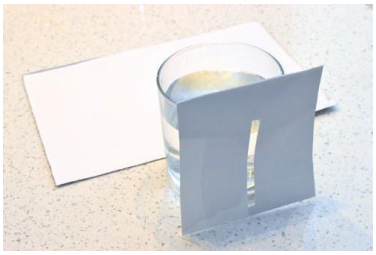
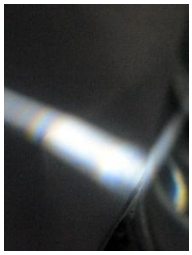
Day 4 –

Today, you will explore the phenomenon of refraction and continue to explore how the brain continues to play tricks by making our own 2D optical illusion.

Time	Activity and Description
15 minutes	**Refraction** Let us perform a magic trick!

	- Draw two short identical arrows on paper pointing in the same direction – one below the other with enough space between them - Place an empty glass/beaker in front of it so that it is touching the paper. - Partly fill the glass so that one of the arrows is visible through the water in the glass and the other can be seen through the air above the water. - Gradually move the glass away from the paper. How is what you see different from what you drew on the paper? How does it change as you move the glass away from the paper?  Refraction (bending of light) happens when light travels between two mediums. In the refraction experiment above light travels from the arrow through the air, through the glass, the water, the glass again and the air again before reaching your eyes.
5 minutes	**Seeing and Interpreting** The previous experiment showed us how the direction of the arrow changed because of refraction. However, sometimes we see things that are actually untrue!  Observe this image – are the lines straight or skewed? The lines are actually straight! It is the pattern of boxes that makes it look crooked. While our eyes see things and capture images, the brain is actually what processes these and makes sense of them. Often, we can trick the brain with different colours, light, and patterns and these are called optical illusions. For example, what do you see in these images? Does everyone have the same response?  Image 1  Image 2  Image 3 - In image 1, some people see a tree while others see a gorilla and a lioness facing each other. - In image 2, some people see a girl, while others see a man with a moustache. - In image 3, some people see a duck, while others see a rabbit! Optical illusions are not just about what our eyes see but also how our brain interprets what our eyes see!

15 minutes	**Make Your Own Optical Illusion** You can make your own optical illusions with clever use of lines and patterns. Below are a few examples.  Outline your hand on paper. Draw rows of straight lines, except inside the outline, where you will curve it to give it a 3D effect.  How many prongs can you see?  Create a perception of depth on flat paper using lines and angles!  Give an illusion of a shape bending. Alternatively, make your own optical illusion based on the perception of colour.  While these two boxes are the same colour, if the light falls from the top left, the two squares appear tilted away from us. In this case, we notice the upper block as lit and the lower block in shadow due to the light source coming from the upper left of the image. Our brain leads us to believe this even when it is not the case Other examples are shared below:  
5 minutes	**Brain Tricks: Orthographic Mapping**

	It is not just images our brain interprets, but words too! The mental process that we use to store words so they can be automatically recognized is called orthographic mapping. Reading words without sounding them out means we have more time to understand what we read. For example, if I put common words in front of you which are orthographically mapped in your brain, you'll feel compelled to read them — your brain does it for you automatically before you decide whether to read or not. For example, try to force yourself not to read the sentence below while looking at it. Our eyes are magical! Was it possible?
At home activities	Explain how refraction plays a role in the following: - Pickles in the jar appear bigger than they really are. - To catch fish in an aquarium, stand so that you are looking straight down into the tank and not looking at them through the glass. - The bottom of a lake is deeper than you actually think it would be. Give more examples of how refraction can be observed in daily life.
Optional Extension	**Make A Rainbow** - Fill two-thirds of the glass (clear glass) with water. - Cut a narrow rectangle in the middle of a piece of paper. - Stick the paper to the glass (see figure) - Place another piece of paper on the floor at the opposite side of the glass to catch the rainbow. - In a dark room, point the flashlight at the slit.   - Which colours can you see? - How do you think white light splits into these colours? *When light passes from one medium to another medium of a different density (e.g. from air to water), the light bends. This is known as the **refraction of light**. How much light is refracted depends on the wavelength of the light. The shorter the wavelength, the more it bends. Because lights of different colours have different wavelengths, each colour is refracted by different amounts. Therefore, white light is split up after passing from air to water and the individual colors become visible. The splitting of light into its colours is known as the **dispersion** of light.*

	A rainbow is formed when sunlight is refracted on entering a droplet of water, reflected inside the back of the droplet and finally refracted again on leaving the droplet.

Day 5 –

Learners will think about all the tricks they have learned and create their own optical trick!

Time	Activity and Description

20 minutes	**Making a Trick**
	We have observed the various tricks that can be played over the course of the last few days. Today, let us create our own trick!
	- Think about what kind of a trick you would like to create.
	- Think about the concepts involved in the trick:
	  - reflection (irregular reflection, lateral inversion, multiple mirrors etc),
	  - refraction (prisms, light moving from one medium to another etc),
	  - eyes and brain (perception of colour, blind spot, afterimages etc)
	- If you can, draw a diagram showing how the light travels during this trick!

15 minutes	**Presentations** ***Note:*** *Ask learners to bring their friends/ family to the class for the presentation.* Demonstrate your trick to your friends/ family and ask them to guess how it happened! After that, explain the trick to them, describing how different concepts were used in it. Finally, ask them if they enjoyed the trick and seek their feedback.
5 minutes	**Reflection** Think and answer these questions: - What did you enjoy during this project? - What did you find difficult? - Could you trick your audience? Why or why not?

Additional enrichment activities:	**Nature Photography Project** Challenge learners to go outside and capture photographs that highlight the interaction of light with nature. Encourage them to focus on phenomena like rainbows, reflections, or shadows. They can print and showcase their best photographs in a class gallery, along with short descriptions of how light played a role in each image. **Magic Tricks With Mirrors** Learners can explore and enact magic tricks that use mirrors and have a magic show in class.
Modifications for	If it is challenging to draw ray diagrams, the teacher can draw them as demonstrations for the learners.

simplification	

ASSESSMENT CRITERIA

A majority of my students were able to:

☐ Explain different types of reflection and the principle of refraction.
☐ Explain how the human eye reflects light.
☐ Distinguish between a concave and a convex mirror.
☐ Use examples to explain how our brain helps us see.
☐ Design an optical illusion and trick the audience!