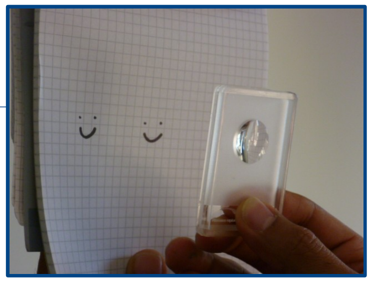
The Light Way

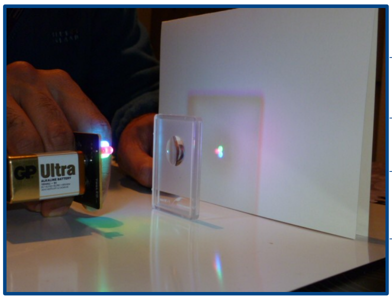
Is seeing believing? We all know that light travels in straight lines. But scientists have found a way to bend light and control it very accurately – using lenses. You can use lenses to make things look different than they are and also learn how astronomers gaze into the stars!



1) **For this experiment** you will need the set of three lenses. Take each lens and hold it about 20 cms from your eye. Ask your team mate to hold an object (e.g. a soft drink bottle cap, smiley face drawn on a page) behind the lens and move it closer and farther away from the lens. Observe the images and write down what you see in a table. Make additional columns or rows that you need using your own titles.

Type of lens	Focal length	Image distance	Image size	…
bi convex				
…				
…				

2) **Set** the 30 mm focal length lens on the table and hold it straight and steady. Instead of the bottle cap, you will use the LED's. Ask your team mate to light up all 3 LED's and hold it behind the lens. Ask a third person in your group to move a white piece of paper (the screen) on the other side of the lens until they see a sharp image of the LED's. You may need to adjust the distance of the LED's and the screen. Make notes about this image (e.g. orientation, location...)



Repeat the experiment, but this time use the lens with the -30 mm focal length lens and do not change anything else. Can you make a similar sharp image on the screen?

3) What you have just seen on the screen is a ***real image.*** The bi-convex lens bends the light rays such that they actually meet at a point on the other side of the lens and an image forms. With the bi-concave lens you cannot find the image anywhere because the light rays do not actually meet. The lens actually makes the rays diverge from each other. You can trace them back behind the lens (on the same side as the object). To the eye, the rays only appear to be coming from this point. This, therefore, is a ***virtual image.*** This is what you saw in Part 1) when the object was up close to this lens.

4) In 2), is there another way to form a *virtual* image with the +30 mm lens instead of replacing the lens? Find out for yourself!

You will now *step into the shoes of Galileo and Kepler: two famous astronomers who built the first known telescopes and opened our eyes to the mysteries of the universe. You will find out how each of their telescopes worked by building them yourself!*

5) **Can you make a telescope** with just one lens? Discuss with your group what your telescope should do and decide what is the least number of lenses you would need to make a telescope.

6) **Galileo's telescope** used a *'negative eye-piece' and a positive lens*. Use the *-30 mm focal length* lens as the eye-piece and hold it quite close to your eye. The *+150 mm focal length lens* is your positive lens which you can use to focus on a far away object. Move the larger lens till the object comes into focus. How does the image look? Ask your team member to measure the distance between the lenses and comment on it. (Remember the telescope works best with far away objects, so focus on something outside a window in your class or across the room, like a poster on the far away wall).

7) **Repeat the experiment** but with a *'positive eye-piece' and a positive lens*. Use the *+30 mm focal length* lens as the eye-piece.. This is **Kepler's telescope** What do you see and how is it different from Galileo's version?

8) **Both the telescopes** magnify the object that you look at – you can even work out how much they magnify the object using the relationship given below. If you get a negative number what do you think this means?

$$\text{Magnification} = -\frac{\text{Focal length of positive lens}}{\text{Focal length of eyepiece}} = \_\_\_\_\_\_\_\_\_\_$$

Magnification =