Mirror Set for the Optics Expansion Kit
(Order Code M-OEK)

The Mirror Set consists of a concave mirror, a convex mirror, and a half screen. When used with components from the Optics Expansion Kit (order code OEK) and a Vernier Dynamics Track (order code TRACK), basic experiments on mirror optics can be performed.

The Mirror Set allows students to investigate image formation from concave and convex lenses.

Parts included with the Mirror Set

- Fixed Convex Mirror (–200 mm focal length, shown above at left)
- Half Screen (shown above, at middle)
- Adjustable Concave Mirror (200 mm focal length, shown above at right)

NOTE: Vernier products are designed for educational use. Our products are not designed nor recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

Closely Associated Products to the Mirror Set

- The Mirror Set is part of a larger set of accessories for the Dynamics Cart and Track System (order code DTS).
- The Dynamics System includes low-friction carts and a combination track/optics bench. Parts from the Optics Expansion Kit, the Polarizer/Analyzer Set, and the Mirror Set all share a common design and mount on the track.
- The Optics Expansion Kit includes lenses, apertures, a screen, a light source, and a light sensor holder. Most experiments with the Mirror Set require the light source from the OEK.
- The Polarizer/Analyzer Set includes three polarizers, one of which can be used with a Vernier Rotary Motion Sensor to measure angles.

Common Holder Design

The two mirrors and half screen all use similar plastic holders. These holders snap to the track with a slight pull to the side. The base unit has fiducial marks to locate the center line of a screen, sensor, light or lens held by the base. You can read the scale on the track through the hole in the base unit.

Mirror Holders

The mirror holders have the mirrors permanently mounted. Do not remove the mirrors. The convex mirror is fixed in position. The concave mirror can be rotated about a vertical axis in order to offset the image slightly to the half screen.

Screen Holder Assembly

A half screen is used so that light from a luminous source can pass through the open area, reflect from the convex mirror, and then fall on the screen region.

Light Source Assembly (not included with Mirror Set)

The light source is part of the Optics Expansion Kit, and is not part of the Mirror Set. However, most experiments require the light source, so it is described here for convenience.

The light source uses a single white LED. A rotating plate lets you choose various types of light for experiments. The open hole exposes the LED to act as a point source. The other openings are covered by white plastic to create luminous sources. The figure “4” is for studying image formation, and is chosen since it is not symmetric left-right or up-down. The “L” shape is 1 by 2 cm in size. The double-slit is used for depth-of-field experiments.

The plane of the luminous sources is located in the plane of the position marked by the pointer on the base. In contrast, the LED point source is located at the back edge of the holder base. This location is important to note for accurate distances in inverse-square experiments.

The power supply provided with the OEK is the same as the power supply for LabQuest® and LabQuest Mini. A rocker switch on the back of the light source turns the light on and off.

Basic Assembly

To quickly see how the Mirror Set can be used, try the following setup.

1. Attach the light source to the track at the 20 cm mark, directed along the track toward higher values. Set the disk to display the “4” object. Connect power and turn on the LED.
2. Place the Adjustable Concave Mirror at the 80 cm mark, facing the light source.
3. Place the half screen at about 50 cm. Either orientation is fine.
4. Now adjust the mirror so that the image of the “4” is visible on the screen. Adjust the screen position to sharpen the image if necessary.

You have now captured the real, inverted image cast by the mirror.

Basic assembly

Sample Experiment: Real Image Formation by Concave Mirror

The basic assembly above demonstrates real image formation by a concave mirror. Try other separations between the object and mirror and examine how the image position changes. You will find that as you move the object toward the mirror, the distance from the mirror to the image increases (i.e., the separation between the object and image decreases).

Sample Experiment: Image and Object Distances for a Concave Mirror

In the basic assembly example above, the object distance is 600 mm and the image distance about 300 mm. This is consistent with a mirror focal length of 200 mm, seen by using the thin lens or mirror equation

$$\frac{1}{f}=\frac{1}{i}+\frac{1}{o}$$

Note that the radius of curvature for a concave mirror is related to the focal length by $2f = r$, so that the radius of curvature of this concave lens is 400 mm.

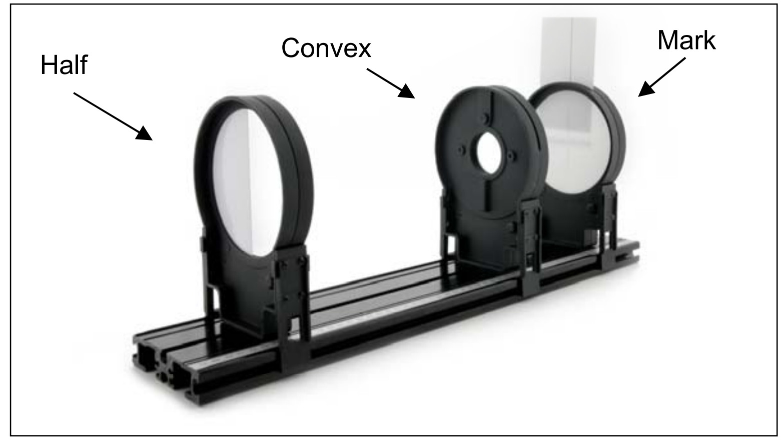
Sample Experiment: Virtual Image Formation by Concave Mirror

A concave mirror casts a virtual image when the object is closer than the focal length to the mirror. To see this, modify the basic assembly by placing the object closer than the focal length of the mirror (e.g., within 200 mm of the mirror). You should see an upright, virtual image. Adjust the position of the screen and try to capture this image. You will find that you cannot, even though the image is easily seen by the eye.

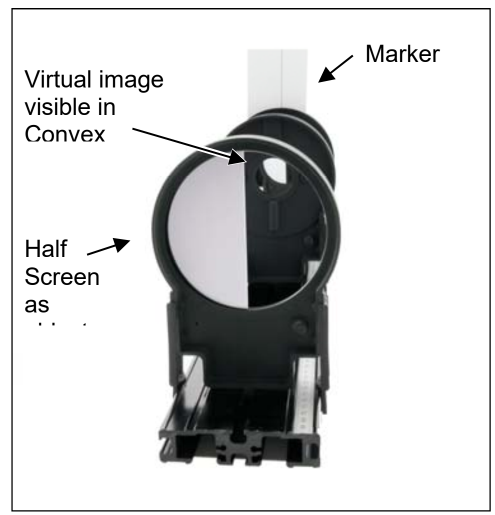
Sample Experiment: Virtual Image Formation by Convex Mirror

Locating a virtual image is somewhat more difficult because it cannot be projected onto a screen, like a real image. The technique described below involves the use of parallax to determine the position of the virtual image.

1. Draw a vertical line on a 3″ x 5″ index card; place this card in the slot on the full viewing screen. Place the Half Screen (which serves as the object), Convex Mirror and Full Screen (from the Optics Expansion Kit) on the track as shown below.



2. Move the Convex Mirror to a position 40 to 50 cm from the Half Screen. Record this as the object distance. Stand at the end of the track near the Half Screen so that you can view both the virtual image of the Half Screen and the index card attached to the full screen as shown below.
3. Position the index card and screen serving as the position marker just behind the convex mirror. Position your head directly behind and above the Half Screen. As you look over the top of the screen toward the mirror, you can view the Half Screen in the mirror, as illustrated on the following page. Note that the line on marker and the edge of the half screen are aligned.



4. Move your head to the right of the Half Screen. Note that the edge of the screen in the image appears to the right of the line on the marker. When you move your head to the left of the Half Screen you should note that the edge in the image shifts to the left of the marker line. This difference in relative positions is called parallax.
5. Move the marker 5 cm farther from the mirror. Note that when you repeat Step 4, the parallax is reduced. Gradually move the marker farther from the mirror and check the alignment of the edge of the screen and the line on the marker until there is no parallax. Record this distance as the distance of the virtual image.

Sample Experiment: Image Magnification by Concave Lens

The linear magnification M of a mirror or lens is

$$M = \frac{-i}{o} = \frac{h_i}{h_o}$$

where h_i is the image height, and h_o is the object height. With a sharp image formed by the concave lens, use a ruler to measure the height of the image and object and compare to your prediction.

Advanced Physics with Vernier–Beyond Mechanics

Another resource for optics experiments is the second book of our two-volume advanced physics set, *Advanced Physics with Vernier–Beyond Mechanics*. Experiments are designed for an interactive teaching style, with planned moments for instructor or student-led discussion. This book examines various topics in electricity and magnetism, as well as thermodynamics, and includes an experiment on mirrors and real images which utilizes the Mirror Set.

Sensors used with the Mirror Set

No sensors are typically used with mirror experiments.

Other Products for Use with the Mirror Set

Dynamics Cart and Track System (DTS)

The Vernier Dynamics Cart and Track System consists of a 1.2 m track, two carts, and related accessories. The system is designed for use in physics and physical science courses for motion and energy experiments.

Polarizer/Analyzer Kit (PAK-OEK)

The Polarizer/Analyzer Set extends the Optics Expansion Kit to allow students to study polarization of light. Using a Rotary Motion Sensor to record analyzer angle, Malus's Law experiments are easy, detailed, and accurate.

Optics Expansion Kit (OEK)

Add the Vernier Optics Expansion Kit to your Vernier Dynamics System to conduct optics experiments, such as image formation with lenses and light intensity *vs.* distance. You can even use the kit to build a basic telescope. The OEK includes two convex and one concave lenses, a screen, a light source, light sensor holder, and an aperture plate.

Warranty

Warranty information for this product can be found on the Support tab at **www.vernier.com/gdx-cl**

General warranty information can be found at **www.vernier.com/warranty**

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Rev. 3/20/2024