Optics Expansion Kit

(Order Code OEK)

The Vernier Optics Expansion Kit (OEK) is a set of lenses, holders, a light source, a sensor holder, aperture plate, and a screen for use with the Vernier Track. The required Track is available separately or as a part of the Vernier Dynamics System. Students can perform basic optics experiments with this equipment. Some typical experiments done with the system include

- Thin lens image formation from a converging lens
- Thin lens equation
- Image formation by a convex lens
- Focal length measurement
- Simple telescope construction
- Microscope
- Inverse-square law of light intensity from a point source
- Lens diameter and shape effects on image

The OEK requires the addition of a Vernier Light Sensor, an interface, and a data-collection application for performing the inverse-square experiment. Appropriate interfaces include the Vernier LabQuest® 2, LabQuest, or LabPro® interfaces, the Vernier Go!®Link, and the Texas Instruments CBL 2™. Appropriate software includes Logger *Pro*® for computers, LabQuest App for LabQuest 2 or the original LabQuest, EasyData™ and DataMate™ for calculators, and DataQuest™ for the TI-Nspire™.

What is included with the Optics Expansion Kit?

The Optics Expansion Kit is shipped in one box containing the following parts:

- Light source with power supply
- Screen with holder
- Light sensor holder
- Aperture disc and holder
- 100 mm focal length double convex lens in holder
- 200 mm focal length double convex lens in holder
- –150 mm focal length double concave lens in holder

Common Holder Design

The lens holders, screen holder, aperture plate, light source and light sensor holder 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. Read the scale on the track through the hole in the base unit.

Lens Holders

The lens holders have the lenses permanently mounted. Do not remove the lenses.

Screen Holder Assembly

The screen is marked with a millimeter scale.

Light Source Assembly

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 at the position marked by the pointer on the base. In contrast, the LED point source is located at the back edge of the holder. 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. A rocker switch on the back of the light source turns the light on and off.

Light Sensor Holder

The light sensor holder is used to position a Vernier Light Sensor for inverse-square law experiments. Insert a Vernier Light Sensor until it reaches the stop. The location of the sensor can then be read from the arrows on the base.

Aperture Disc

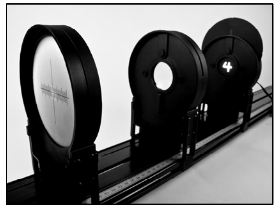
An aperture disc can be placed immediately adjacent to a lens in order to vary the effective diameter and shape of the lens. Experiments regarding f/stop and brightness can thus be performed. A D-shaped aperture allows the "half a lens" demonstration to be performed.

Sample Experiments: Real Image Formation

The thin lens equation is

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

where f is the lens focal length, i is the image to lens distance, and o is the object to lens distance. Sign convention for f is positive for converging lenses, negative for diverging. The variable i is positive if the (real) image is in back of the lens, and negative if the (virtual) image is in front. The variable o is positive if the (real) object is in front of the lens, and negative if the (virtual) object is behind the lens.



This relationship can be verified using the Optics Expansion Kit. Place the light source near the end of the track, with the luminous source facing along the longer length of the track. Insert the 100 mm focal length lens into a holder, and place it 15 cm from the light source plane. Place the screen on the side of the lens opposite the light source. Where do you find a sharp image? Is it where you expect it using the thin lens equation?

The linear magnification M of a 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. Use a ruler to measure the height of the image and object. Does the linear magnification you observe match the prediction?

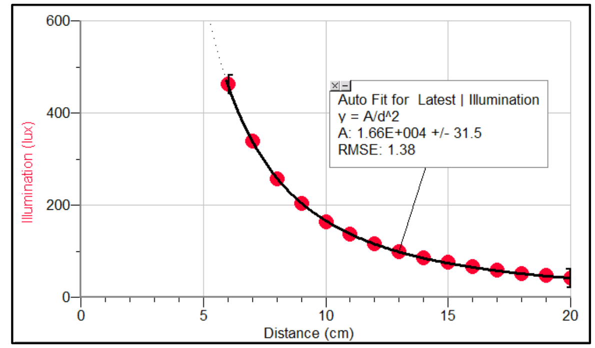
Sample Experiments: Inverse Square Law

This experiment requires a light sensor, interface, and associated software. In this example we will use Logger *Pro* software, a Go! Link, and a Vernier Light Sensor.

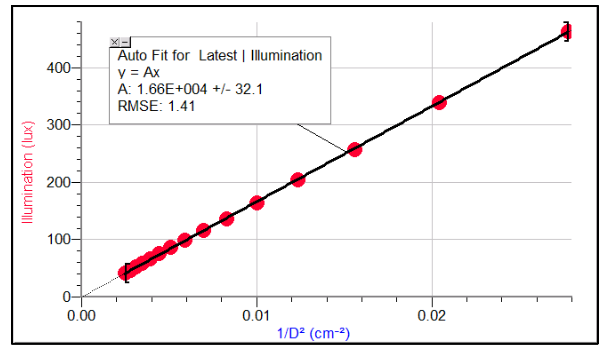
Position the light source so that the LED is exposed and is facing down the length of the track. Read the position using the back edge of the carriage for the light source.

Attach a light sensor to the light sensor holder. Insert a Vernier Light Sensor until it reaches the stop. The location of the sensor can then be read from the arrows on the base. Position the sensor so it is pointing directly at the light source. Allow the light source to stabilize for 15 minutes before collecting data. The intensity falls slightly as the LED warms, so for this experiment, warm-up time is required.

Collect intensity data as a function of distance. Sample data with curve fits are shown in the following two graphs.



The light intensity follows the expected inverse-square relationship well. Another way to show this relationship is to graph light intensity *vs.* the inverse of the squared distances. The resulting graph should be a direct proportionality. The next graph shows this result.



The room was partially darkened during data collection. If there is substantial background light, both graphs would be shifted upward, and the fits would require an additive term.

Additional Experiments

- Make a telescope by combining convex lenses at the sum of focal lengths.
- Study the effect of lens size and shape on image formation. Set up the luminous source, a converging lens, and the screen so that you see a real image on the screen. Position the aperture plate as close to a lens as possible, and observe the effect of different size apertures. You may need to dim the room lights to see the changes. What will happen with the D-shaped opening?
- Study depth-of-field by casting a real image of the two slits on the screen, and then take it out of focus by moving the screen until you can no longer resolve the two lines. Use the aperture plate to make the working diameter of the lens smaller. How does this change the image?

Other Products for Use with the Optics Expansion Kit

Vernier Dynamics System (VDS)

The Vernier Dynamics System consists of a track, two low-friction dynamics carts, and associated accessories for dynamics experiments.

Vernier Light Sensor (LS-BTA)

The Vernier Light Sensor approximates the human eye in spectral response and can be used over three different illumination ranges, which can be selected with a switch.

Track-to-Track Coupler (T2T-VDS)

The Track-to-Track Coupler rigidly connects two tracks for larger experiments and demonstrations.

Combination Dynamics Track/Optics Bench (TRACK)

The track is a low-friction black anodized track and optics bench combination designed for kinematics, dynamics, and optics experiments.

Mirror Set (M-OEK)

The Mirror Set extends the kit to allow students to easily study image formation by concave and convex mirrors. The set includes a concave mirror, a convex mirror, and a half screen for viewing images formed by mirrors.

Color Mixer Kit (CM-OEK)

The Color Mixer Kit consists of a three-color LED source, a lens, and a screen. These can be used to study the mixing of red, blue, and green light by additive and subtractive mixing.

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.

Diffraction Apparatus (DAK)

The Diffraction Apparatus consists of a laser light source, a collection of diffraction and interference slits, and a novel Linear Position Sensor and High Sensitivity Light Sensor.

Warranty

Vernier warrants this product to be free from defects in materials and workmanship for a period of five years from the date of shipment to the customer. This warranty does not cover damage to the product caused by abuse or improper use.

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