Geometric Optics: Basics

In **Geometric Optics: Basics**, students discover how an image is formed by a lens or mirror using ray diagrams.

Lens Screen

Determine how the focal length and diameter affect where the image is formed and how it appears (magnification, brightness, inversion). Create real and virtual images and experiment with a spotlight.

CHOOSE object

MOVE object

ADJUST optic parameters

HIDE rays and image

MEASURE image/object distances

SET your Preferences; **CHANGE** focal length control mode

Mirror Screen

Form images using a flat mirror. Adjust the object distance and diameter of the mirror and observe the effects on the image position, magnification, and brightness.

**LOCK** to prevent vertical object movement

ZOOM in/out

SELECT ray type

PLACE markers to predict or measure

LABEL the items

Complex Controls

- The Preferences menu can be used to change the focal length controls and enable the 2F Points checkbox.
- The light propagation toggle button which hides the rays/image/light spot and can be used for predictions or triggering the ray tracing animation.
- To constrain the movement of the object to horizontal motion only, use the lock button next to the object selection menu.
- The Guides feature can be enabled using the `addGuidesCheckbox` query parameter. The Guides indicate the extent to which light refracts through a lens, and the angle between the guide arms is proportional to the focal length. The Guides may be useful when predicting the location of the image, or can be used to emphasize the way light is focused. The Guides will align to the Marginal Rays when the object distance is twice the focal length.
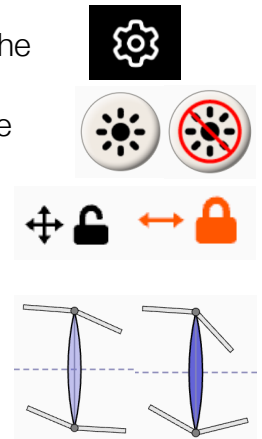
Insights into Student Use

- Students may experiment with placing the object at the focal point. However, this is not always possible when using the indirect focal model controls, as the minimum object distance is 40 cm.
- Students may need scaffolding to interpret the image brightness when the image is smaller than the object. When |M|<1 the light forming the image is more intense, so changes in object distance and optic diameter will appear to have less of an effect on image brightness.

Suggestions for Use

Sample Challenge Prompts
- Sketch the formation of an image using principal rays.
- Explain the difference between a real and virtual image.
- Find all the ways to change the brightness of the image.
- Predict where an image will be formed given the object distance and focal length.

Customization Options

Query parameters allow for customization of the simulation, and can be added by appending a '`?`' to the sim URL, and separating each query parameter with a '`&`'. The general URL pattern is:

`…html?queryParameter1&queryParameter2&queryParameter3`

For example, in Geometric Optics Basics, if you only want to include the 1st screen (`screens=1`), with the audio disabled (`audio=disabled`) use:

https://phet.colorado.edu/sims/html/geometric-optics-basics/latest/geometric-optics-basics_all.html?screens=1&audio=disabled

To run this in Spanish (`locale=es`), the URL would become:

https://phet.colorado.edu/sims/html/geometric-optics-basics/latest/geometric-optics-basics_all.html?locale=es&screens=1&audio=disabled

⚙ Indicates this customization can be accessed from the Preferences menu within the simulation.

Query Parameter and Description	Example Links
⚙ `focalLengthControl` - specifies how the focal length is controlled, and can be either `direct` (focal length slider) or `indirect` (radius of curvature and index of refraction sliders). Default is `direct`.	`focalLengthControl=indirect`
⚙ `add2FPointsCheckbox` - when `true`, adds a checkbox to the control panel to display the 2F points. Default is `true`.	`add2FPointsCheckbox=false`
`addGuidesCheckbox` - when `true`, adds a checkbox to the control panel to display the Guides, see Complex Controls above. Default is `false`.	`addGuidesCheckbox=true`

`screens` - specifies which screens are included in the sim and their order. Each screen should be separated by a comma. For more information, visit the Help Center.	`screens=1`
	
	 `screens=2,1`

`initialScreen` - opens the sim directly to the specified screen, bypassing the home screen.	`initialScreen=1` `initialScreen=2`
⚙ `locale` - specify the language of the simulation using ISO 639-1 codes. Available locales can be found on the simulation page on the Translations tab. Note: this only works if the simulation URL ends in "_all.html".	`locale=es` (Spanish) `locale=fr` (French)
`audio` - if `muted`, audio is muted by default. If `disabled`, all audio is permanently turned off.	`audio=muted` `audio=disabled`
`allowLinks` - when `false`, disables links that take students to an external URL. Default is `true`.	`allowLinks=false`
`supportsPanAndZoom` - when `false`, disables panning and zooming using pinch-to-zoom or browser zoom controls. Default is `true`.	`supportsPanAndZoom=false`

Model Simplifications

- The perspective of the picture frames implies that the observer is looking from the side. However, an observer would only see an image from this vantage point if there was a screen at the image location. This perspective was chosen to make the ray tracing and inversion/mirroring of the image clearer.
- For consistency, labels appear below the item. For objects, this means that the "Object" label may not be immediately next to the origin of the point source.
- There is a singularity when an object is placed at the focal point, which may result in a flash or stutter.

- The opacity of the framed images is used to indicate its intensity, and depends on the object distance, optic diameter, and magnification of the image. An image will appear dimmer when the object is far from the optic, the optic diameter is small, or the magnification is large.
- In general, the intensity of the light spot on the projector screen is inversely proportional to its diameter. However, intensity will remain constant when the diameter of the lens changes.
- Marginal Rays and Many Rays refract/reflect only at the first point of contact with the optic.
- Principal Rays are a model used to identify the location of an image. However, due to the size of the object, these rays may not always physically reach the optic, so we extend the central axis of the optic to make the ray behavior clearer.
- Many Rays consists of a 120-degree fan of rays. The number of rays will increase with the distance of the object from the optic, so that there are always at least 2 rays incident on the optic.
- In the Light scene, rays that do not interact with the lens will not cast any light on the projection screen, because we are not modeling ambient light.
- When using the indirect focal length controls, the focal length, f, of the lenses is calculated using the Lens-Maker's Equation, assuming thin lenses and an equal radius of curvature, R, on both faces, $f = R/(2(n-1))$ where n is the index of refraction.
- The focal length of the flat mirror is infinite.

See all published activities for Geometric Optics: Basics here.
For more tips on using PhET sims with your students, see Tips for Using PhET.