Geometric Optics: describes light propagation in terms of rays. The ray in **geometric optics** is an abstraction, or instrument, useful in approximating the paths along which light propagates in certain classes of circumstances.

Reflection at a Plane Surface

Law of reflection:

θi=θr

Reflection at a Spherical Concave Surface

* C - radial centre of the mirror.
* f- focus; halfway between C and the mirror.

General patterns:

|  |  |  |  |
| --- | --- | --- | --- |
| **Location of the Object** | **Location of the Image** | **Size of the Image** | **Orientation of the Image** |
| Beyond C | Between f and C | Smaller | Inverted |
| At c | At c | Same Size | Inverted |
| Between f and C | Beyond C | Larger | Inverted |
| At f | At infinity | - | - |
| Between f | Behind the mirror | larger | Normal |

Reflection - General Case

The conventions used here are the same for Refraction - General Case

Assume that the mirror is spherical with radius R.

Convex \Ri R is positive.

Concave \Ri R is negative.

Planar \Ri\ R is ∞.

If f is the focus,

f=−R2

* s - the distance along the optical axis from the mirror to the *object*.
* s′ - the distance along the optical axis from the mirror to the *image*.

ss and s′s′ are positive when they are in front of the mirror (i.e. when they are real) and negative when they are behind the mirror (i.e. when they are virtual).

Mirror Equation (also the thin lens equation):

1s+1s′=1f=−2R

The magnification, m, is the ratio of the size of the image to the size of the object.

m=−s′s

When m is negative, the image is inverted.

Animation Additional idea

Have interactive lenses where you can change the size of lens and the type lens so people could see the effect of light rays on different lenses

Examples from

<http://www.physicsclassroom.com/Physics-Interactives/Refraction-and-Lenses/Optics-Bench/Optics-Bench-Refraction-Interactive>

<http://highered.mheducation.com/sites/0073404535/student_view0/chapter24/interactive__virtual_optics_lab.html#>

Refraction and Snell’s law

Basics and Conventions

Refractive Index:

ni=cvi

where vi is the speed of light in that medium and cc is the speed of light in vacuum.

A real image is one which can be projected onto a screen, whereas a virtual image can only be seen through the lens and appears to exist behind it.

Refraction at a Plane Interface:Snell's Law

n1sinθ1=n2sinθ2

General Case

The conventions here are the same for Reflection-General Case

Assume that the interface is spherical with radius R.

Convex \Ri\ R is positive.

Concave \Ri\ R is negative.

Planar \Ri\ R is ∞∞.

* s - the distance along the optical axis from the mirror to the *object*.
* s′ - the distance along the optical axis from the mirror to the *image*.

s is positive \Ri in front of the interface.

s is negative \Ri behind the interface.

s′ is positive \Ri behind the interface.

s′ is negative \Ri in front of the interface.

In general, s and s′ are positive when they are real and negative when they are virtual.

The following equation approximates the situation,

n/1s+n/2s′=(n2−n1)/R

The magnification, mm, is the ratio of the size of the image to the size of the object.

m=−n1s′/n2s

When mm is negative, the image is inverted.

Terminology

Optical System

Any arrangement of lenses, mirrors, etc., that light passes through.

Object

An actual physical thing that light rays originate from or reflect off of and then pass through the optical system. In diagrams, it is usually drawn as an arrow, the base of which sits on the optical axis at point 'OO'.

Image

Place in the Optical System where the object only appears to be. An image can be the same size, bigger, or smaller than the object. It can have the same orientation as the object or be inverted. An image is real if it can be projected onto a screen (i.e. a piece of paper). A virtual image can only be seen through the lens and appears to exist behind it. In diagrams, an image is usually drawn to scale with the object and indicated on the optical axis as

point 'II'.

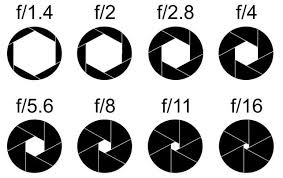
Optical Axis

Most Optical Systems have an obvious symmetry. The Optical Axis runs through this line of symmetry. For example, many optical systems consist of spherical lenses arranged in a straight line. The Optical Axis in these cases is the line that connects the centres of the lenses.

Ray Cone

The set of all possible light rays that can leave the object and pass completely through the optical system.

Aperature (or Stop)

A physical, opaque object that has the ability to "stop" some rays from exiting the optical system. Symbol:

Aperature Stop

The physical object in the optical system that is the limiting factor for the size of the ray cone. It limits the brightness of the image. The Aperature Stop can be an actual aperature, or it can be a lens if the lens's diameter (perpindicular to the optical axis) is small.

Entrance Pupi

The image of the aperature stop as seen from the object. It is the ray cone that the object sees when looking into the optical system.

Exit Pupil

The image of the aperature stop as seen from the final image (i.e. from the "exit" end of the optical system). It is the ray cone that can be seen when looking into the end of the optical system.

Cheif Ray (or Principal Ray)

A ray which goes from the tip of the object to the tip of the final image by passing through the points where the entrance and exit pupils intersect the optical axis. If a pupil is virtual, then the chief ray must pass through the point where the pupil appears to intersect the axis.

Field of View

When looking back through an optical system, the Field of View is a measure of how much you can see. With a small entrance and exit pupil, the field of view is small. For very large objects, a large Field of View is needed for a complete image to be made; especially when the object is close to the entrance pupil. Because of its relation to the entrance and exit pupils, the Field of View is limited by the Aperature Stop.