Physics Notes 2013

Lenses

Recollection - Refraction of Light

Optical Medium: A material that light can pass through. A medium is said to be optically dense if it reduces speed of light. Eg. Light slows down in water.

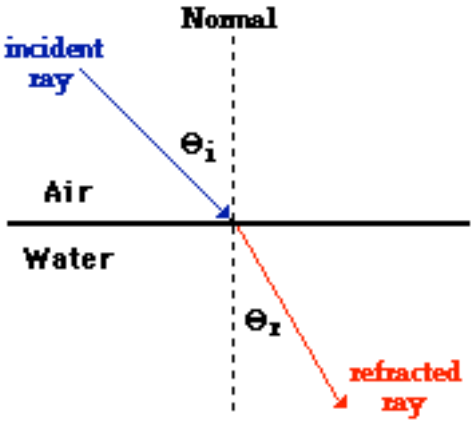
Refraction: Occurs because light travels at different speeds in different media.

Angle between incident ray and normal is the Angle of Incidence, *i*. Angle between reflected ray and the normal is Angle of Reflection, *r*.

As light passes through from a less dense medium to a denser medium, the ray bends towards the normal.

Vice versa for a light ray traveling from a optically denser medium to a optically less dense medium.

When light rays are incident normally on the media boundary, they do not undergo refraction.



Laws of Refraction

1. The incident ray, refracted ray and normal all lie on the same plane.
2. For any given pair of media, $n_i(\sin i) = n_r(\sin r)$ [Snell's Law].

For a light ray passing from air to a given medium, $n = \sin i / \sin r$. The larger the value of reflective index *n* of a medium, the more the light will bend as it enters the medium. Refractive Index can also be defined as n = speed of light in air/speed of light in medium. In addition, it can be determined using n = real depth/apparent depth. [not covered 2012]

The Refractive Index of a few media are shown below.

Material	Refractive Index
Vacuum	1.000
Air	1.0003
Water	1.33
Ice	1.31
Glass	1.53
Paraffin oil	1.40
Diamond	2.40

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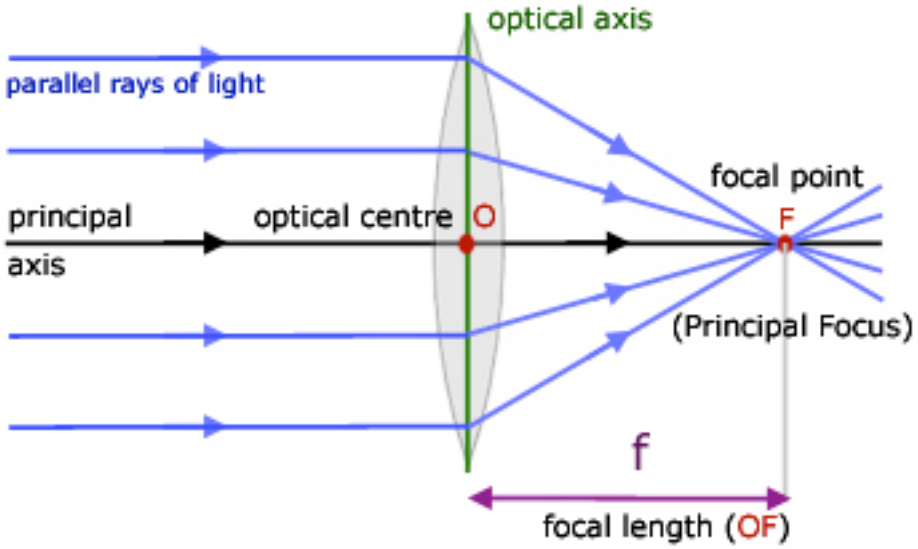
Some Daily Phenomenon of Refraction:

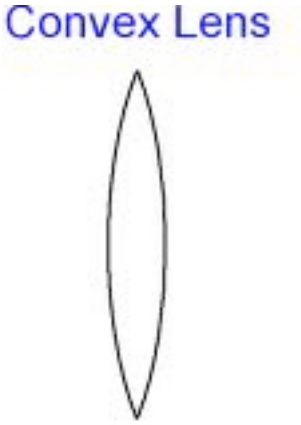
1. Swimming pool appears shallower than it really is.
2. 'Bent' objects [chopsticks] in liquids.
3. Dispersion of white light into its spectrum.

Thin Converging Lenses

Converging Lenses: Also known as convex lenses, converging lenses are thicker in the middle than on the outer edges.

This will cause the light passing though to converge, to bend towards the optical axis. Here is a diagram to illustrate.





Defining Key Terms:

Principle Axis: Line passing through the centers of curvature of the lens.

Principle Focus: Aka Focal Point. A point on the principle axis that parallel rays converge. It
should be noted that the lens could be flipped and the results would be the same for an ideal thin lens.

Focal Length: The horizontal distance between Principle Focus and the optical centre of the lens.

Optical Centre: An imaginary point inside a lens through which a light ray is able to travel without being deviated.

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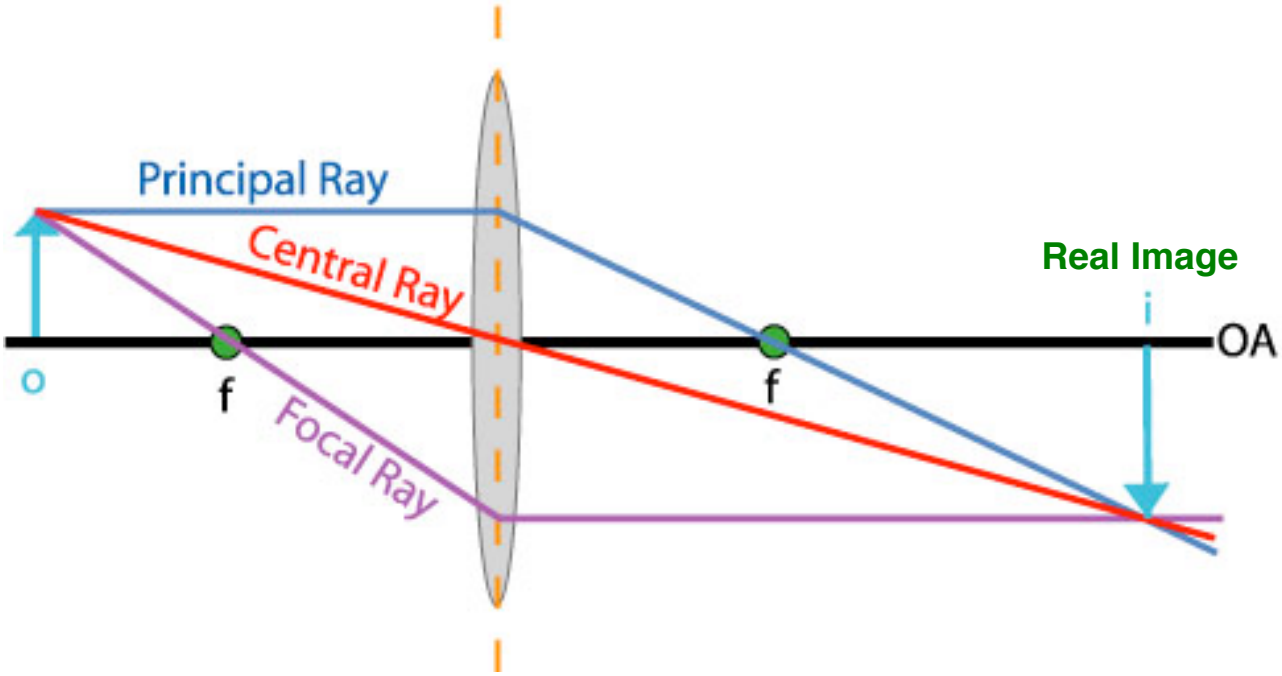
Ray Diagrams



1. Centre Ray: a rat passing through optical center of lens emerges undeflected.
2. Parallel Ray: A ray parallel to the axis on the incident side passes through the focus point on the other side.
3. Focal Ray: A ray through the focus point on the incident side, emerges parallel.

For Example,
If rays originating from an object converges on an image point [can be received on screen], image is called real. If rays do not converge but appear to come from image point, image is virtual.

Lens Equation

Ray diagrams provide useful information about object-image relationships yet fail to provide the information in a quantitative form. Hence the lens equation is used to extract useful numerical data. $1/f = 1/u + 1/v$

Take f = focal length
u = object distance from optical centre
v = image distance from optical centre

Conventions:

1. *f* is positive for converging lenses, and negative for diverging lenses.
2. *u* is positive if object is on the side of the lens from which the light is coming.
3. *v* is positive if image is on the opposite side of the lens from which the light is coming.

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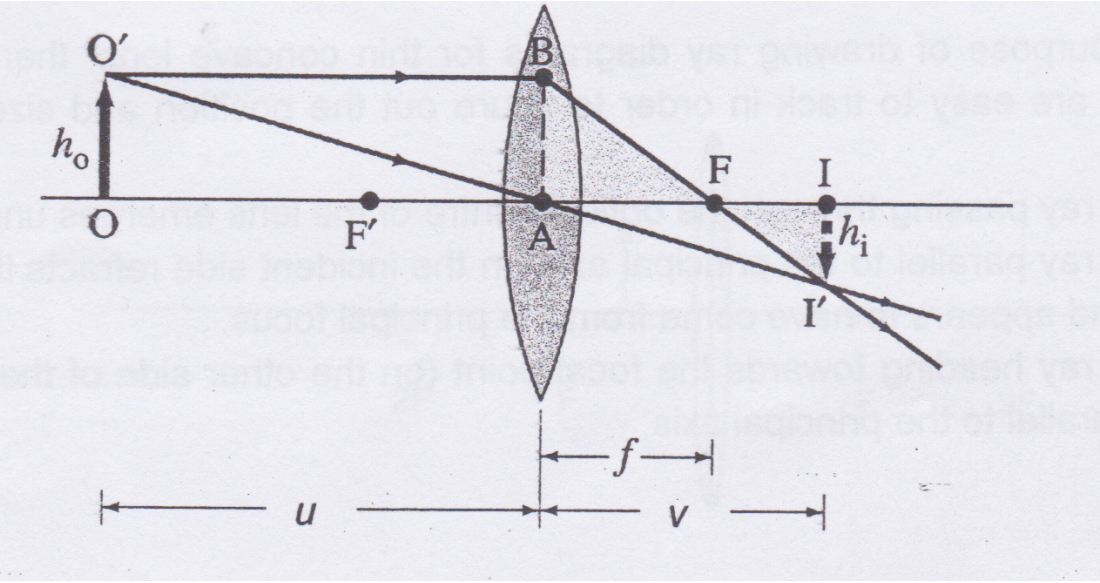

Linear Magnification

Linear Magnification: Ratio of the image size to the object size.

When we look through lenses, image size may differ from actual size, represented by linear magnification factor. Can also be obtained from the ratio of the image distance from optical centre of the lens to object distance from the optical centre of the lens.

If image is larger than object, magnification factor is > 1. Vice versa for image smaller than object.

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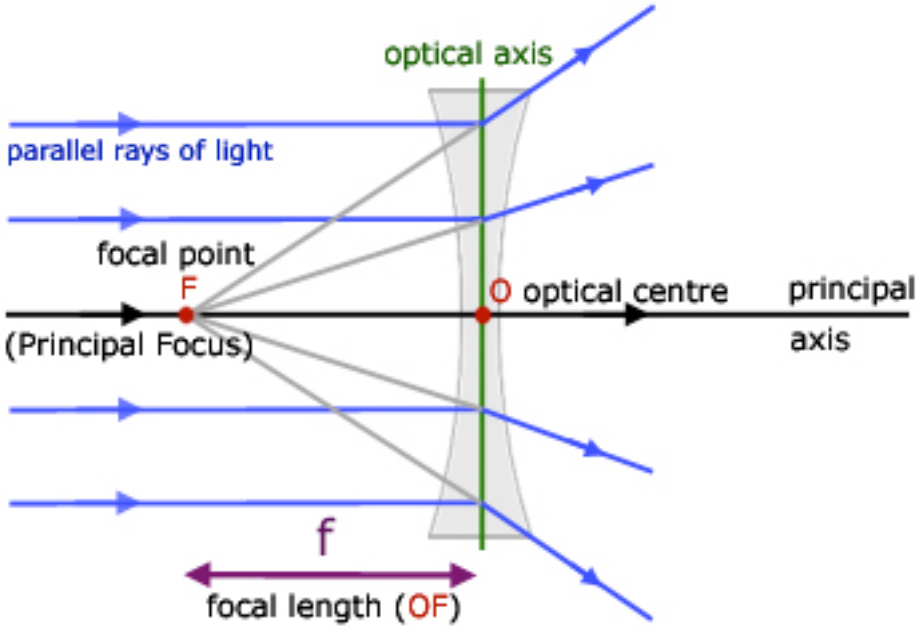
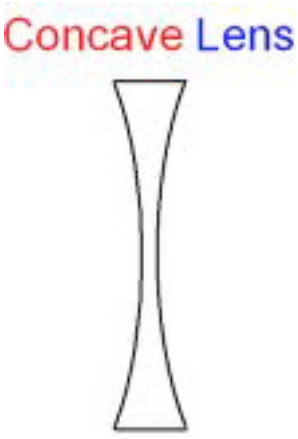
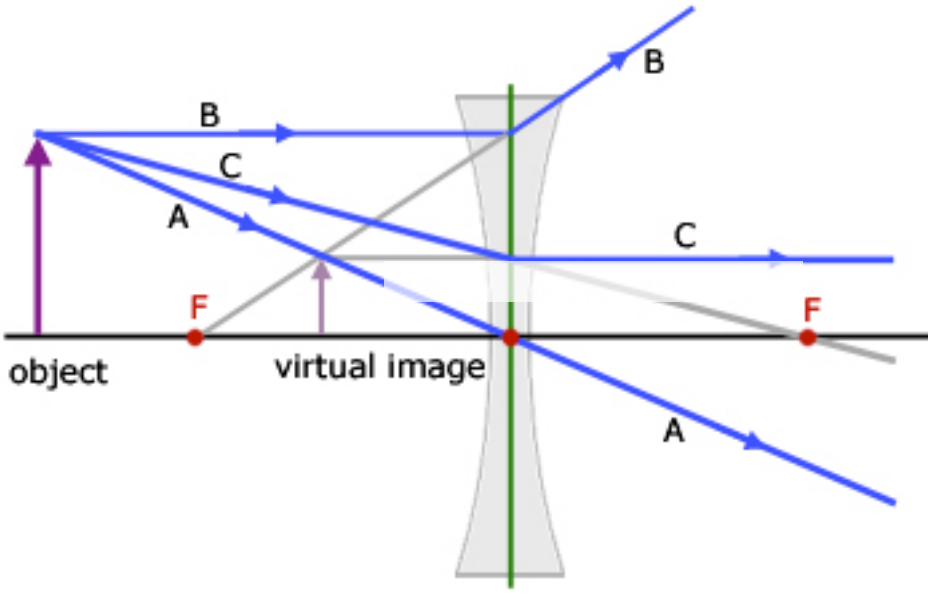
Thin Diverging Lenses





Thin Diverging Lenses: Aka Concave Lenses. They are thinner in the middle than on the outer edges.

This will cause light passing through to diverge, to bend away from the optical axis.



Ray Diagrams

1. A ray passing through the optical centre of the lens emerges undeflected.
2. A ray parallel to the principle axis on the incident side refracts through the lens and appears to have come from the principle focus.
3. A ray heading

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> towards the focal point [on the other side of the lens] emerges parallel to the principle axis.

For concave lenses, regardless of object position, the image produced is always virtual, upright, diminished, and on the same side of the lens as the object.