SNC2D PHYSICS

LIGHT & GEOMETRIC OPTICS

- ☞ Converging & Diverging Lenses (P.448-450)

Curved Lenses

We see the world through lenses even if we do not wear glasses or contacts. We all have natural lenses in our eyes. Lenses are also used in the design of optical devices, such as cameras, microscopes, and movie projectors. Even water droplets can act as natural lenses.

Curved Lenses

*A **lens** is a transparent object used to refract light (i.e. change it's direction). And because of this ability, lenses are used to magnify images or to project images onto a screen*

LENS

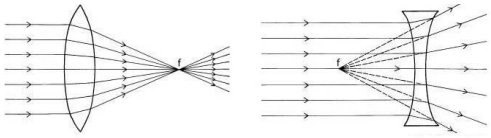
- transparent object used to refract (bend) light

Curved Lenses

NOTE!

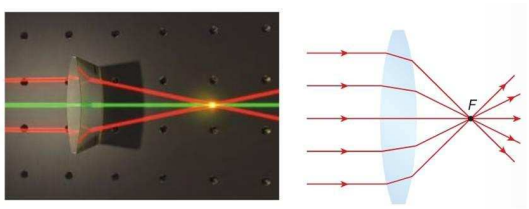
Lenses can be classified into different types according to how they refract light: converging (convex) and diverging (concave). The type of lens is determined by what happens to parallel light rays as they pass through the lens.

CONVERGING (CONVEX) **DIVERGING (CONCAVE)**



Curved Lenses – Converging Lens

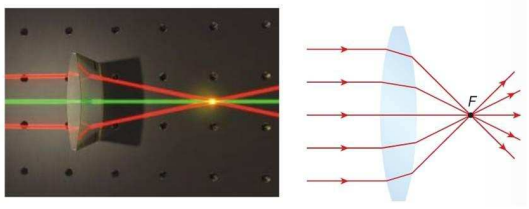
*A **converging** or **convex lens** is thicker in the middle and thinner at the edges. When parallel light rays pass through a converging lens, they are refracted. Because of their change in direction, the rays converge (come together) at a single point called the focus (F).*



Curved Lenses – Converging Lens

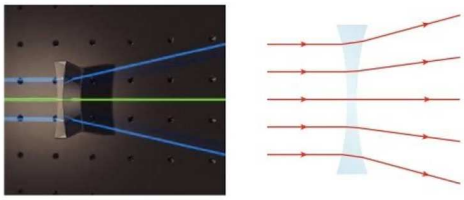
CONVERGING (CONVEX) LENS

- causes parallel light rays to meet or converge at a focal point (F)



Curved Lenses – Diverging Lens

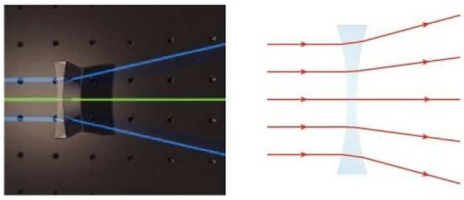
*A **diverging** or **concave lens** is thinner in the middle and thicker at the edges. In a diverging lens, light rays are refracted and diverge (spread apart) as if they are coming from a single point on the other side of the lens – a virtual focus.*



Curved Lenses – Diverging Lens

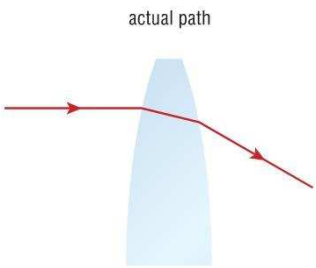
DIVERGING (CONCAVE) LENS

- causes parallel light rays to spread out or diverge from a focal point (F)



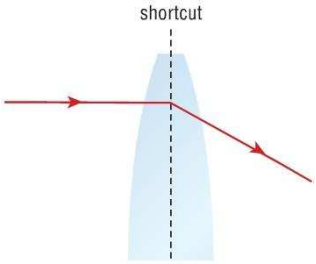
Curved Lenses & Refraction

In order to understand how to draw ray diagrams for lenses, it is important to understand how the incident and emergent rays are related to each other. In a lens, light is refracted at the first air to glass surface. Light then travels through the glass of the lens and is refracted again at the glass to air surface on the other side. This means that there are always two refractions in a lens.



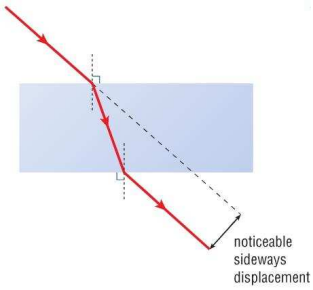
Curved Lenses & Refraction

We are, however, concerned only with the direction of the incident ray entering the lens and the emergent ray leaving the lens. As such, ray diagrams can be greatly simplified by drawing a dashed vertical line through the centre of the lens and showing refraction occurring at this line.



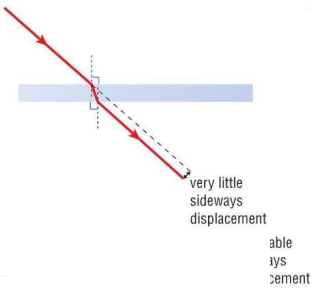
Curved Lenses & Refraction

*Another issue, that only affects converging lenses, is **lateral displacement**. When a light ray passes through a rectangular prism, the emergent ray is parallel to the incident ray but displaced sideways (since the two surfaces are parallel to each other). The amount of sideways displacement depends on the thickness of the prism.*



Curved Lenses & Refraction

Since a very thin rectangular prism results in very little displacement, ray diagrams can be simplified by assuming that the converging lenses we work with are "thin" lenses and as a result the light ray passing through the optical centre passes straight through without being refracted.



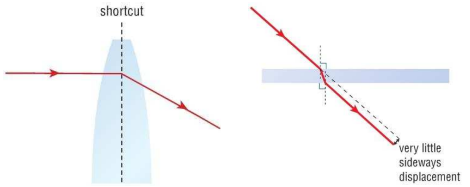
Curved Lenses & Refraction – Assumptions

RAY DIAGRAMS

Two assumptions are made to simplify drawing ray diagrams for lenses.

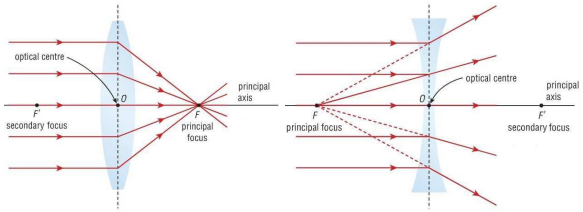
① All refraction takes place along the axis of symmetry.

② The lenses are thin (so very little lateral displacement of light rays).



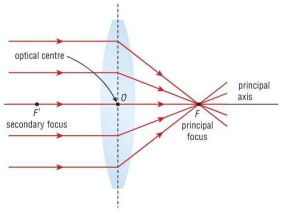
Curved Lens Terminology

*Converging and diverging lenses are described using similar terms. The centre of the lens is called the **optical centre (O)**. The **principal axis (PA)** is a line that runs through the optical centre and the foci on either side of the lens. The dashed vertical line through the centre of the lens is called the **axis of symmetry**.*



Curved Lens Terminology

*Lenses are transparent, so light rays can pass through from both sides. Every lens, therefore has a focus on each side. The **principal focus (F)** of a converging lens is the point where light rays parallel to the principal axis converge after leaving the lens. The other focus is called the **secondary focus (F')**.*

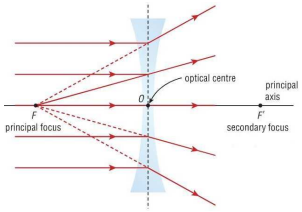


NOTE! *F and F' are located the same distance from O.*

Curved Lens Terminology

In the case of a diverging lens, light rays parallel to the principal axis diverge after leaving the lens. If we project these diverging rays backwards, it looks as if they come from a virtual focus – this point is now the principal focus (F). The secondary focus (F') is now on the other side of the lens, where the rays actually diverge.

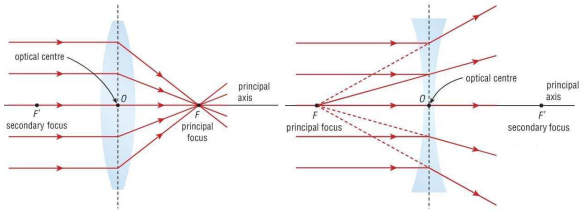
NOTE! *F and F' are located the same distance from O.*



Activity: Curved Lens Terminology for …

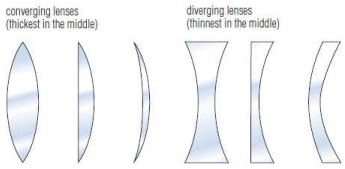
INSTRUCTIONS (2DPHYS - WS6)

A. Complete Part 1 (Converging/Diverging Lens Terminology). Recall that the principal and secondary foci switch sides.



Curved Lens Defects

There is no such thing as a perfect lens. All lenses have imperfections called ***aberrations*** *– including chromatic and spherical aberration, coma, and distortion. There are many techniques to reduce aberrations, but they can never be eliminated. The fewer the aberrations in a lens, the more costly the lens is to produce.*



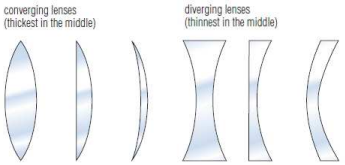
Curved Lens Defects

CHROMATIC ABERRATION

- causes white light passing through the lens to disperse into its spectral components
- an image with coloured fringes is observed

Curved Lens Defects

High-quality optical components account for a large part of the cost of most optical devices. Pressing hot glass, grinding, and polishing processes are time-consuming and expensive. In the last few decades, plastic molding has made inexpensive, high-quality plastic lenses and prisms more readily available.



Curved Lens Defects

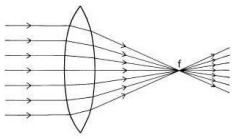
SPHERICAL ABERRATION

- light passing through edge of lens is focused closer to lens than light entering near centre
- a blurred image is observed

✔ Check Your Learning

1. Briefly describe, with the aid of a diagram, what happens to parallel light as it passes through:
   (a) a converging lens.

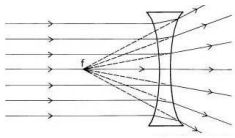
   (a) the rays converge after passing through the lens



✔ Check Your Learning

1. Briefly describe, with the aid of a diagram, what happens to parallel light as it passes through:
   (b) a diverging lens.

   (b) the rays diverge after passing through the lens



✔ Check Your Learning

2. Describe one similarity and one difference between converging and diverging lenses.

   a converging lens causes the light rays to converge while diverging lens causes the light rays to diverge

✔ Check Your Learning

3. How could you tell if a lens was a converging lens or a diverging lens, using your hands and with your eyes shut?

a converging lens bulges outwards in the centre whereas a diverging lens is curved inwards in the centre

✔ Check Your Learning

4. A converging lens of diamond (n = 2.42) and a converging lens of crown glass (n = 1.52) each have the same shape. Which lens will have the greater focal length? Explain your answer with the aid of a diagram.

crown glass (smaller n = less refraction = greater focal length)