Department of Physics/First stage

Optical lab

Dr. Alaa Nizar

Dr. Noha H. Harb

Experiment one

Optical devices

Optical Devices

An Optical device is any technology that uses light can be as simple as a mirror or as complex as the Hubble telescope.

- الجهاز البصري هو أي تقنية تستخدم الضوء يمكن أن تكون الأجهزة الضوئية بسيطة مثل المرآة أو معقدة مثل تلسكوب هابل.

Types of Optical Devices

1- Contact lenses

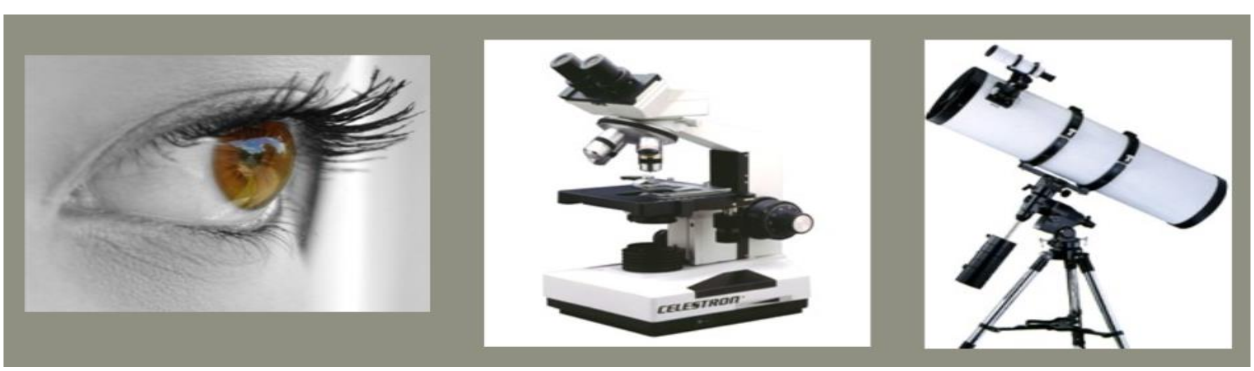
2- Eyeglasses

3- Telescopes

4- Microscopes

5- Camera

- أنواع الأجهزة البصرية (العدسات اللاصقة، النظارات،التلسكوبات، المجاهر، الة التصوير)



What is a Mirror?

mirror is a surface that reflects nearly all kinds of light incidents on it.

- المرآة عبارة عن سطح يعكس تقريبًا جميع أنواع الضوء الذي يسقط عليه.

Working or principle of Mirrors

Mirrors work on the principle of **reflection**.

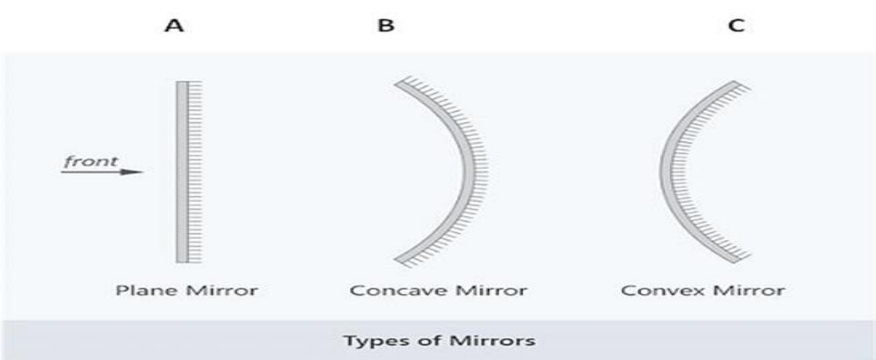
- تعمل المرايا على مبدأ الانعكاس

Mirrors are **polished** from **one side** so that they can reflect more light and form a clear image

Types of Mirrors

- Plane Surface Mirror
- Concave Mirror
- Convex Mirror

- أنواع المرايا(مستوية ، مقعرة، محدبة)



What is a Lens?

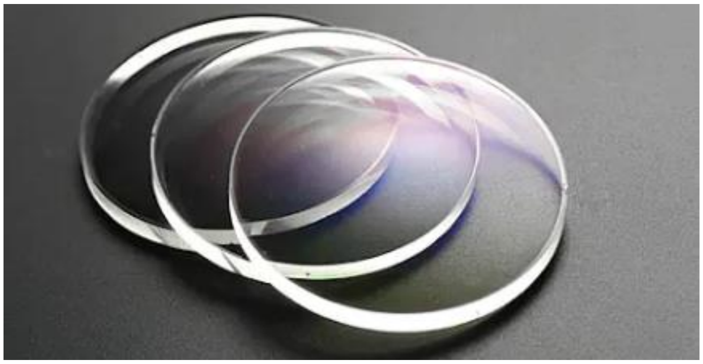
Lens is a piece of glass or any transparent material with curved sides to concentrate and disperse light.

- العدسة عبارة عن قطعة من الزجاج أو أي مادة شفافة ذات جوانب منحنية لتركيز الضوء وتشتيته.

Working or principle of Lenses

Lenses works on the principle of **refraction**.

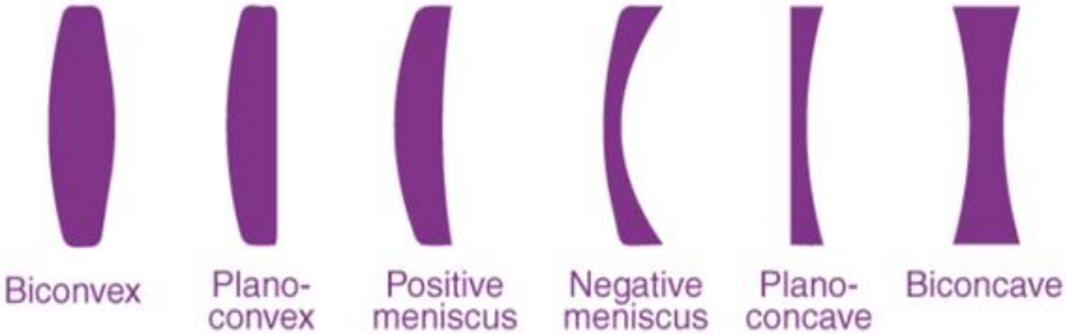
- عمل العدسات على مبدأ الانكسار.



Types of Mirrors

1. Convex Lenses.
2. Concave lenses.

- لعدسات المحدبة والعدسات المقعرة هما أكثر أنواع العدسات شيوعًا.



- **Why are converging lenses used?**

Converging lenses are used to make things appear larger.

- **Why are diverging lenses used?**

Diverging lenses are used to make things appear smaller.

<u>What is Lens Formula?</u>

In optics, the relationship between the distance of the image (v), the distance of the object (u), and the focal length (f) of the lens is given by the formula known as the Lens formula.

$$\frac{\mathbf{1}}{\mathbf{v}} + \frac{\mathbf{1}}{\mathbf{u}} = \frac{\mathbf{1}}{\mathbf{f}}$$

<u>Question</u>

Q1: What the difference between the lens and mirror?

Q2: Write lens formula?

Q3: What the application of Concave lenses?

Q4: What the application of Concave mirror?

Experiment 2

Find the Refractive Index of a Liquid by Using a Convex Lens and Plane Mirror

Aim

Find the Refractive Index of a Liquid by Using a Convex Lens and Plane Mirror

Materials Required

Convex lens, liquid, plane mirror, retort stand with clamp and pin, spherometer, meter rule

Theory

Let us consider f_1 and f_2 to be the focal length of the glass convex lens and liquid lens respectively and let F be the focal length of their combination, then

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

From the lens maker's formula

We have,

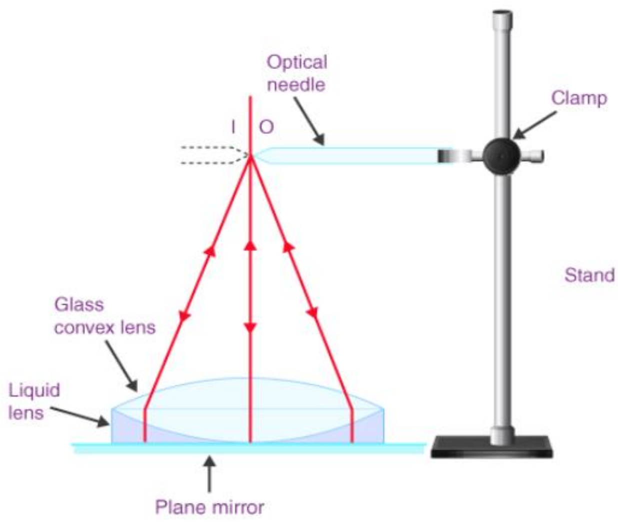
$$\frac{1}{f_2} = (n-1)[\frac{1}{R_1} - \frac{1}{R_2}]$$

Simplifying further, we get

$$\frac{1}{f_2} = \frac{(n-1)}{R}$$

Inserting values of f_2, n can be calculated.

Diagram



Procedure

1- Place the plane mirror on the horizontal base of the iron stand.
2- Place the convex lens on the plane mirror, and its focus is found by locating the position of the pin where it coincides with its own image. By measuring from this point to the lens, its focal length (f1) is found.
3- The lens is now removed, and a few drops of liquid are placed on the mirror. On placing the convex lens on the liquid, a combination of a convex (glass) and a Plano-concave (liquid) lens results.
4- The focal length (f) of the combination is found as above, and the

focal length (f2) of the liquid lens calculated from f and f1 (equ. (1))

5- The radius of curvature (r) of the lens surface in contact with the liquid is now obtained by a spherometer , or by boys, method.
6- Calculate the refractive index of liquid from equation (2).

Calculations

$$\frac{1}{f_2} = \frac{1}{F} - \frac{1}{f_1} \quad \ldots\ldots\ldots\ldots\ldots..(1)$$

$$n = 1 + \frac{R}{f_2} \ldots\ldots.\ldots\ldots\ldots\ldots(2)$$

Question

Q1: What is the Refractive Index of a medium?

Q2: What are the laws of reflection?

Q3: Can the refractive index of a medium be less than or equal to 1?

Experiment 3

Determine Refractive Index of a Glass Slab Using a Traveling Microscope

Aim

Determine the refractive index of a glass slab using a travelling microscope.

Materials Required

1. Travelling microscope.
2. glass slabs of different thicknesses but the same material.
3. Lycopodium powder.

Theory

The principle behind glass slab

When a glass slab is placed on a horizontal surface, and its bottom surface is viewed from the top, it appears to be elevated due to refraction. The apparent thickness of the slab is determined by the distance between the apparent bottom and the top of the glass slab. The refractive index with respect to the medium and air is given as:

$$n = \frac{real\ thickness\ of\ the\ slab}{apparent\ thickness\ of\ the\ slab}$$

Procedure

1- To get sufficient light, place the travelling microscope (M) near the window.
2- Mark point P on the microscope's base using black ink.
3- Let R1 be the vernier scale and main scale reading on the vertical scale.
4- Let R1 be the vernier scale and main scale reading on the vertical scale.
5- Place the glass slab with the least thickness over the mark P.
6- Let P1 be the image of the cross mark. Move the microscope upwards and focus on P1.
7- For reading, R2 on the vertical scale repeat step4.
8- Sprinkle a few particles of lycopodium powder on the slab's surface.
9- To focus the particle near S, raise the microscope further upward.
10-For reading, R3 on the vertical scale repeat step 7.
11-Repeat the above steps for different thickness glass slabs.
12- Record the observations.

Observations and Calculations

Table for microscope readings

Sl. no	Reading on a vertical scale when a microscope is focused on			Real thickness $(R_3 - R_1)$ in cm	Apparent thickness $(R_3 - R_2)$ in cm	Refractive index $n = \frac{R_3 - R_1}{R_3 - R_2}$
	Cross mark without slab R_1 in cm	Cross mark with slab R_2 in cm	Lycopodium powder R_3 in cm			
1.						
2.						
3.						

Experiment 4

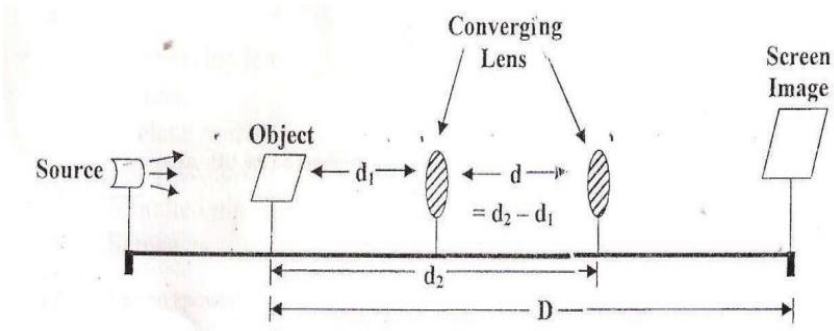
The Focal Length converging Lens (Displacement Method)

Aim

Determine the focal length of a converging lens by the lens displacement method.

Materials Required

Converging lens, Meter scale, Object pin, Screen



Procedure

Method:

1. Place the object (o) at one end of meter scale and the image screen

(I) at the end so that distance apart is about 90 cm.

[The distance between the object and screen is (D)]

2. Place the lens between then and near to the object.

3. Adjust the position of the lens until MAGNTIEF IMAGE is sharply

focus on the screen.

4. Record the position of the lens along scale.

The distance between the lens and object is = d1.

5. Move the lens toward the screen and adjust its position one again a diminished image is sharply in, focus on the screen.

6. Record the new position of the lens along scale.

The distance between the lens and object is = d2.

7. Repeat the observation with the distance between the object and screen (D) equal to, 80.70.60.50 cm.

Reading:

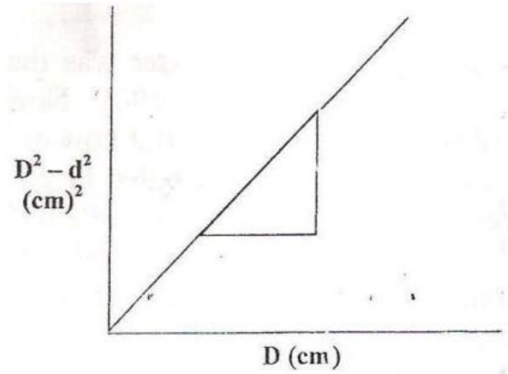
Distance between object and image D (cm)	First position of lens (d_1)	Second position of lens (d_2)	Lens displacement $d = d_1 - d_2$
90 80 70 60 50			

** Plot the graph between ($D^2 - d^2$) against D will be a straight line through the origin whose slop is the numerical value (4F).

Slop = $\frac{D^2 - d^2}{D}$

F = $\frac{D^2 - d^2}{4D}$

Therefore, F = $\frac{Slope}{4}$



Question

Q1. What is the principle of the lens displacement method?

Q2. Differentiate between convex lens and concave lens?

Q3.What is the focal length of a lens?

Experiment 5

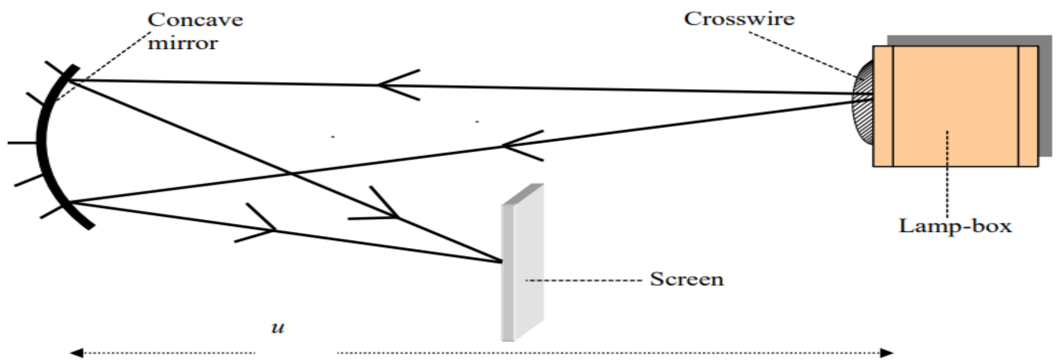
Determination of Focal Length of Concave Mirror

Aim

Determine the focal length of concave mirror.

Materials Required

Concave mirror, screen, and lamp-box with crosswire.



Procedure

1. Place the lamp-box well outside the approximate focal length - see notes.

2. Move the screen until a clear inverted image of the crosswire is obtained.

3. Measure the distance u from the crosswire to the mirror, using the meter stick.

4. Measure the distance v from the screen to the mirror.

5. Calculate the focal length of the mirror using

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

6. Repeat this procedure for different values of u.

7. Calculate f each time and then find an average.

Observation Table

Results

u/cm	$\frac{1}{u}$/cm^{-1}	v/cm	$\frac{1}{v}$/cm^{-1}	$\frac{1}{f}$/cm^{-1}	f/cm

Average f =

Question

Q1. Name two Types of spherical mirrors

Q2. What is the relationship between focal length and the radius of curvature R of a concave mirror?

Q3. What is the mirror formula?

Q4. What is law of reflection for a mirror?

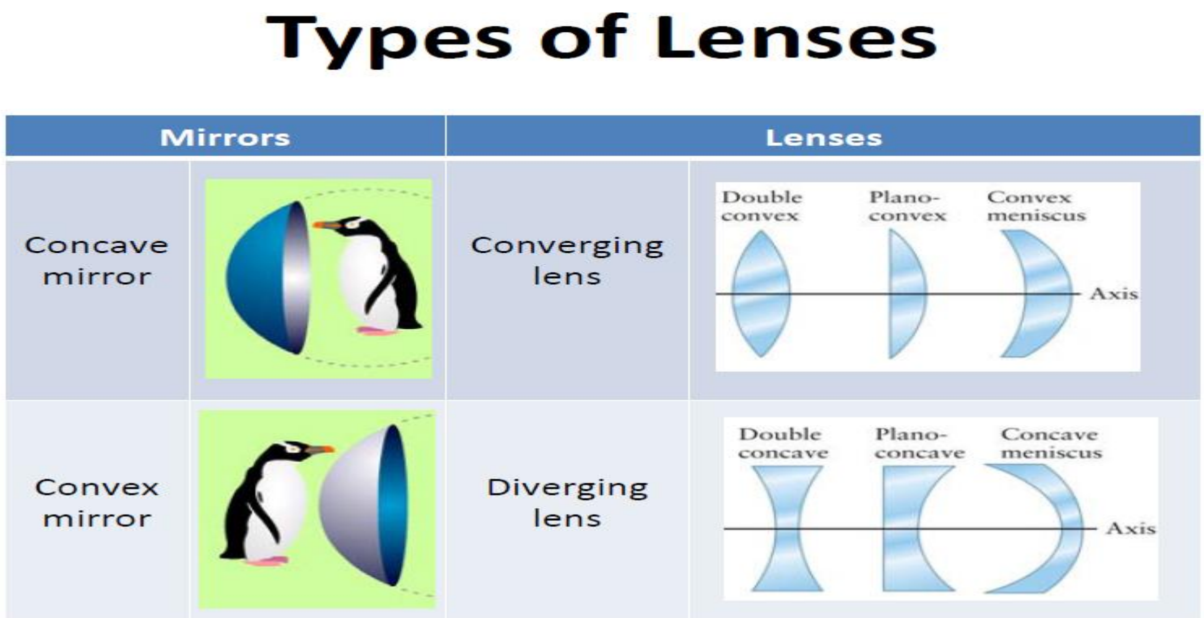
Experiment 6

Virtual experiment: Types of Lenses

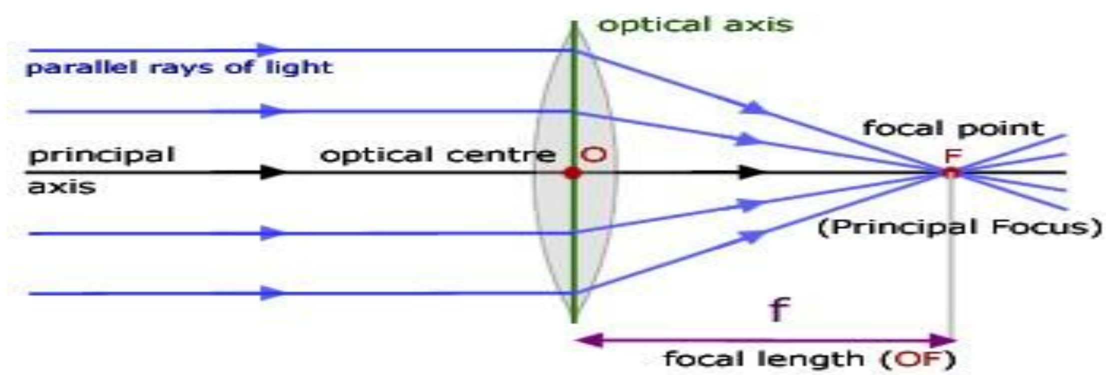
Aim

A virtual experience to learn about the types of mirrors and lenses and the conditions in which images are formed using PhET

Theory



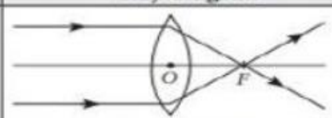
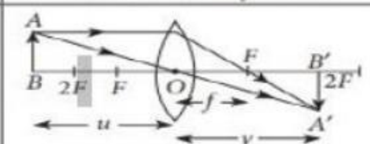
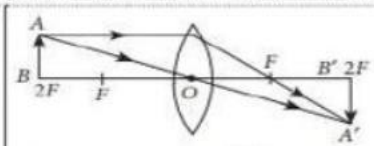
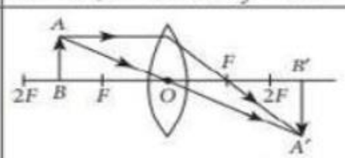
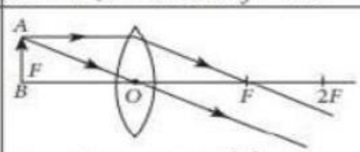
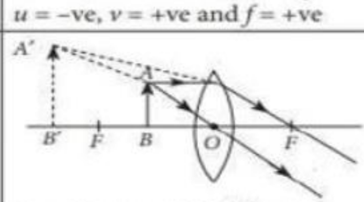
<u>Convex Lenses Basic ray diagram</u>

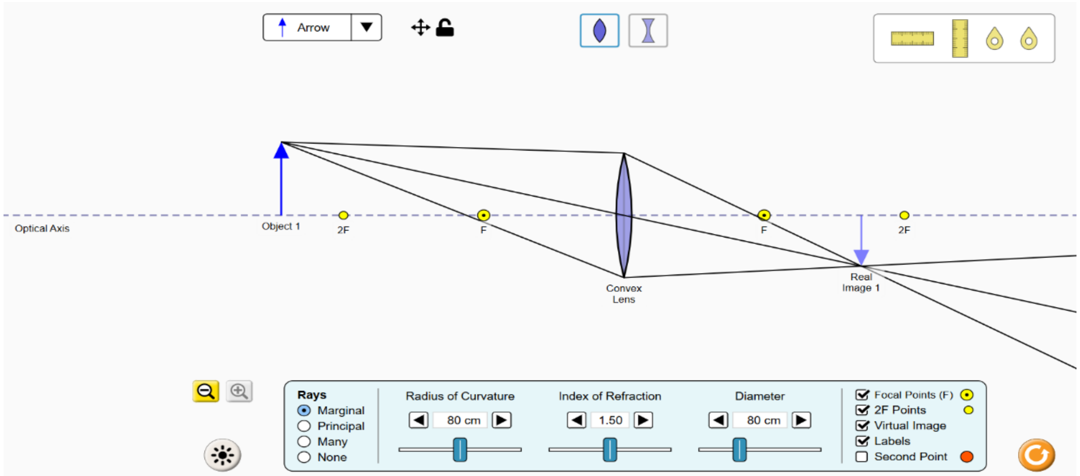


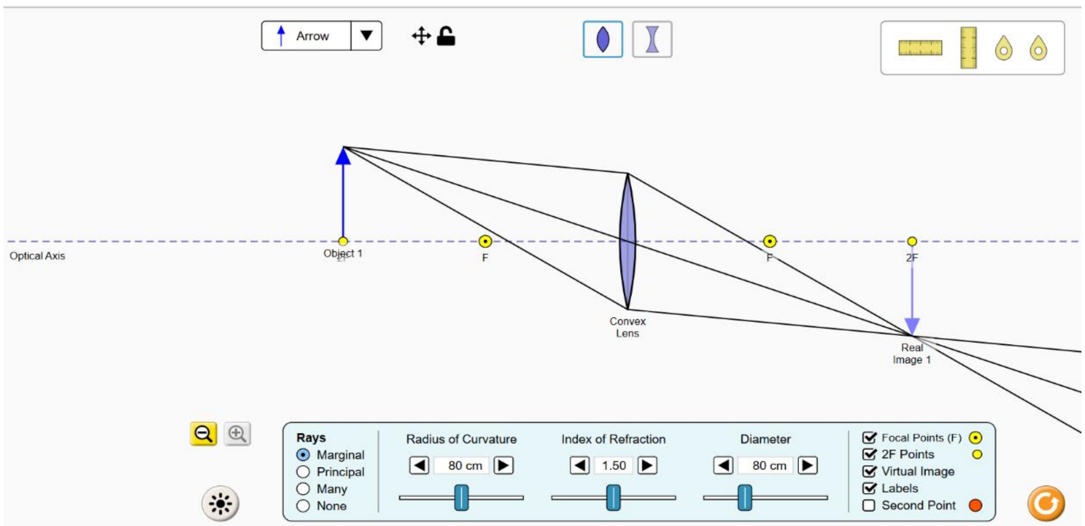
The basic ray diagram for a convex lens introduces a number of important terms

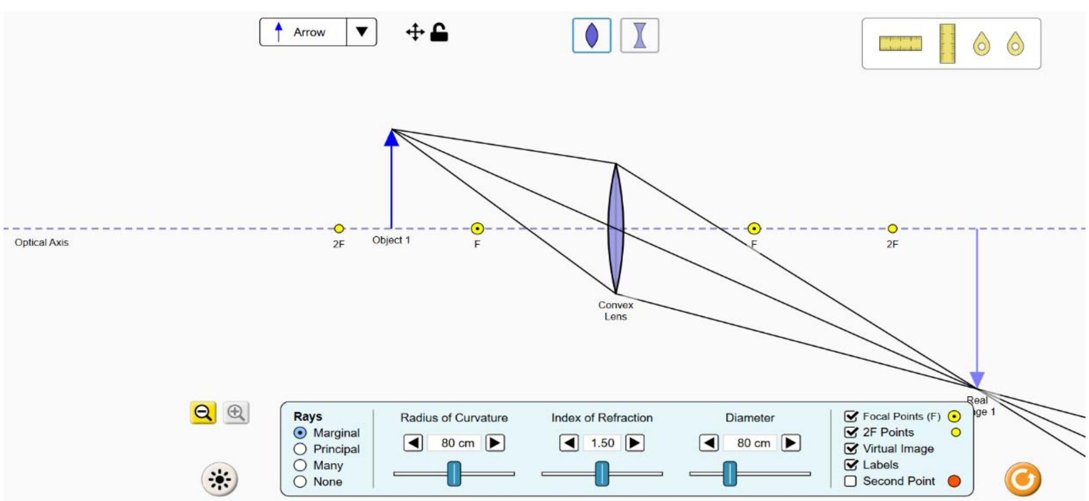
- principal axis - the line passing through the centers of curvature of the lens
- focal length - the horizontal distance between the principal focus and the optical center of the lens
- optical center - an imaginary point inside a lens through which a light ray is able to travel without being deviated
- center of curvature - the center of the sphere of which the lens surface is part**.**

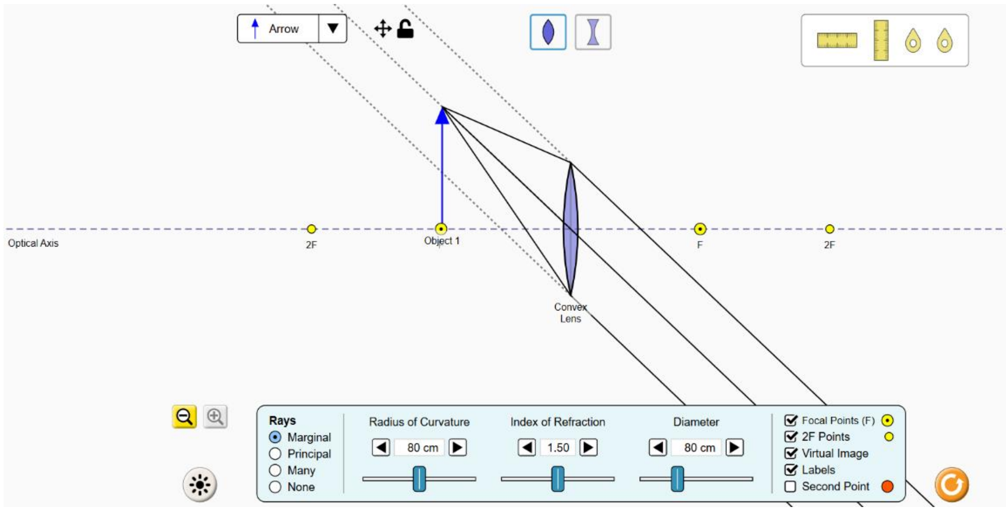
► **Image formation by lenses :**

	Convex lens			
	Ray diagram	**Position of object**	**Position of image**	**Nature of image**
(a)	 $u = -ve$, $v = +ve$ and $f = +ve$	At infinity	At F	Real, inverted and highly diminished
(b)	 $u = -ve$, $v = +ve$ and $f = +ve$	Between infinity and $2F$	Between F and $2F$	Real, inverted and diminished
(c)	 $u = -ve$, $v = +ve$ and $f = +ve$	At $2F$	At $2F$	Real, inverted and same sized
(d)	 $u = -ve$, $v = +ve$ and $f = +ve$	Between F and $2F$	Beyond $2F$	Real, inverted and enlarged
(e)	 $u = -ve$, $v = +ve$ and $f = +ve$	At F	At infinity	Real, inverted and enlarged
(f)	 $u = -ve$, $v = -ve$ and $f = +ve$	Between F and O	On the same side of the lens	Virtual, erect and enlarged


Arrow
Optical Axis
Object 1
2F
F
F
2F
Convex Lens
Real Image 1
Rays
Marginal
Principal
Many
None
Radius of Curvature
80 cm
Index of Refraction
1.50
Diameter
80 cm
Focal Points (F)
2F Points
Virtual Image
Labels
Second Point


Arrow
Optical Axis
Object 1
F
F
2F
Convex Lens
Real Image 1
Rays
Marginal
Principal
Many
None
Radius of Curvature
80 cm
Index of Refraction
1.50
Diameter
80 cm
Focal Points (F)
2F Points
Virtual Image
Labels
Second Point


Arrow
Optical Axis
2F
Object 1
F
F
2F
Convex Lens
Rays
Marginal
Principal
Many
None
Radius of Curvature
80 cm
Index of Refraction
1.50
Diameter
80 cm
Focal Points (F)
2F Points
Virtual Image
Labels
Second Point



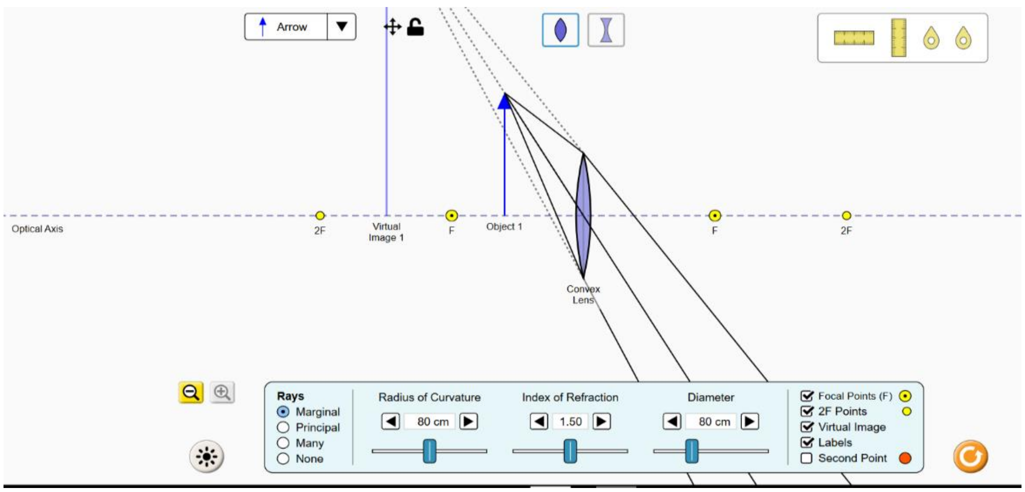
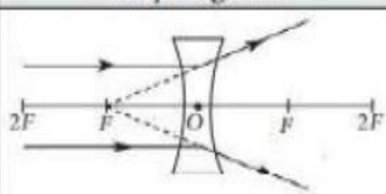
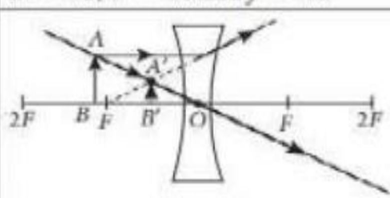
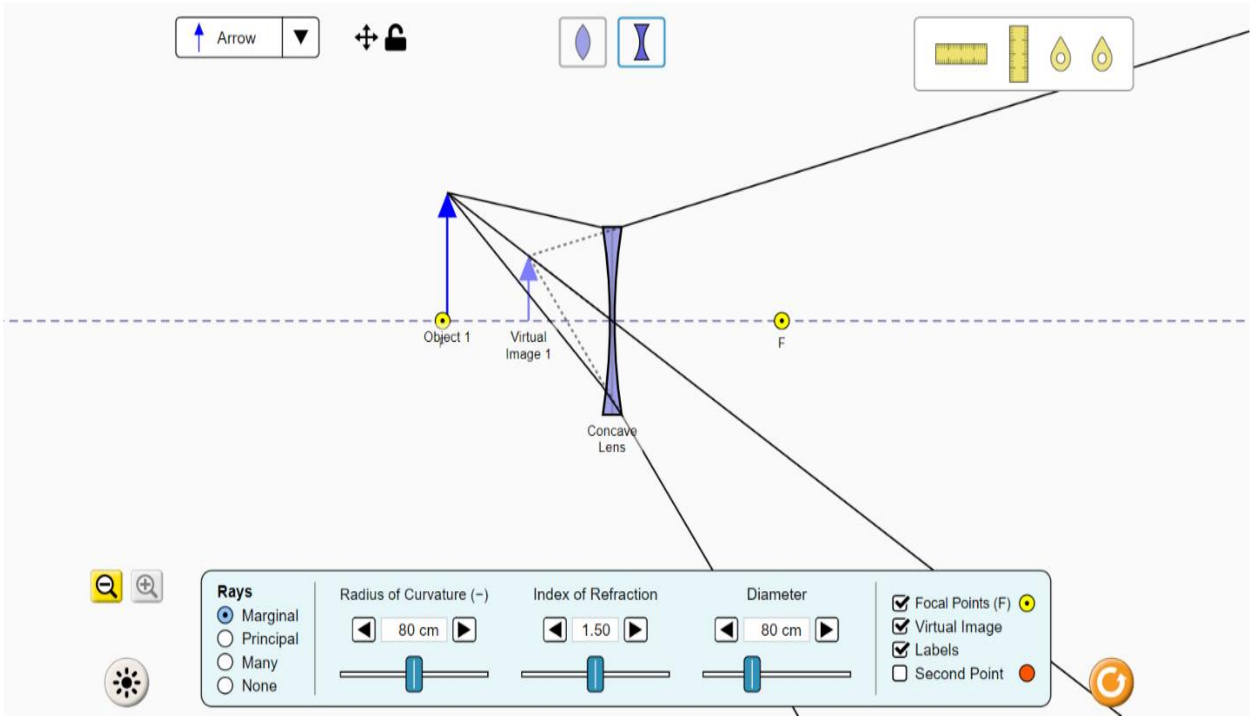
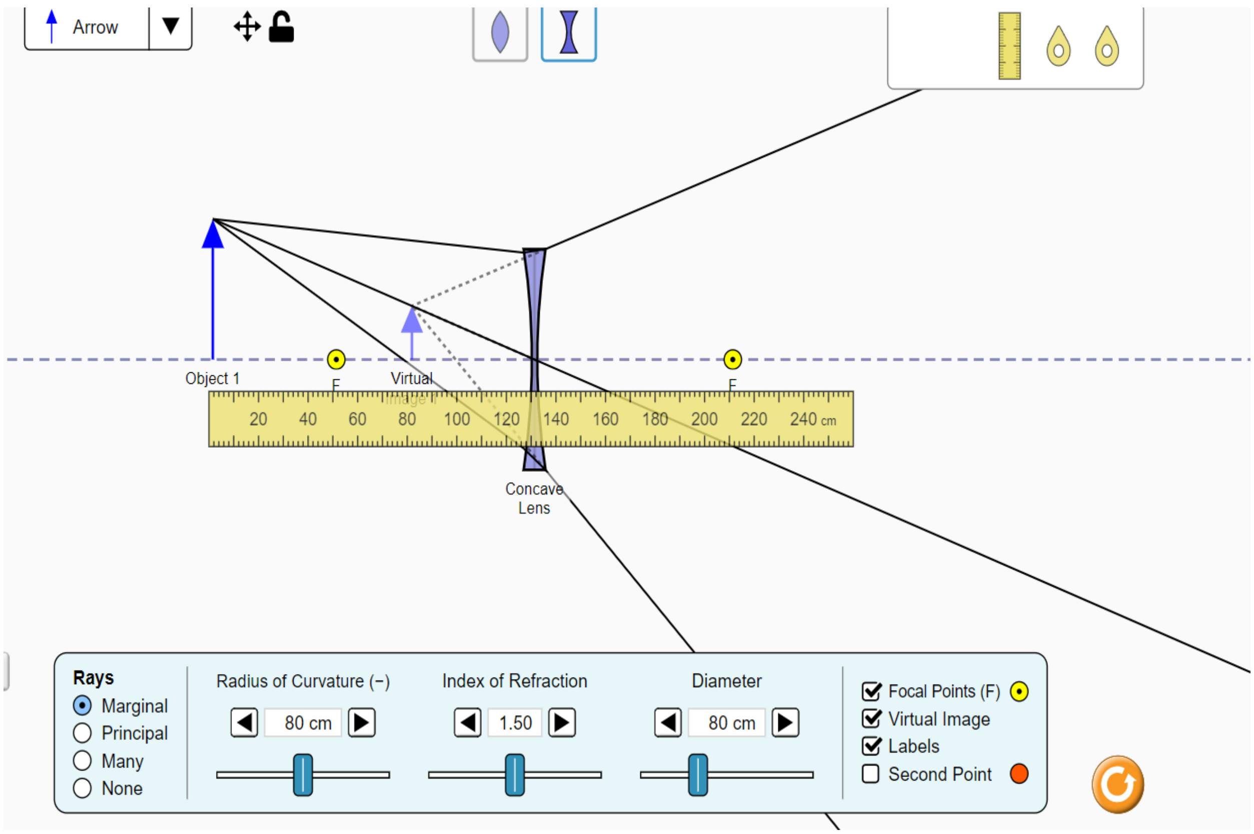


Image formation by a concave lens :

Concave lens				
	Ray diagram	Position of object	Position of image	Nature of image
(a)	 u = –ve, v = –ve and f = –ve	At infinity	At F	Virtual, erect and highly diminished
(b)	 u = –ve, v = –ve and f = –ve	Between infinity and O	Between F and O	Virtual, erect and diminished


Arrow
Object 1
Virtual
Image 1
F
Concave
Lens
Rays
Marginal
Principal
Many
None
Radius of Curvature (−)
80 cm
Index of Refraction
1.50
Diameter
80 cm
Focal Points (F)
Virtual Image
Labels
Second Point


Arrow
Object 1
F
Virtual
Image 1
F
20 40 60 80 100 120 140 160 180 200 220 240 cm
Concave
Lens
Rays
Marginal
Principal
Many
None
Radius of Curvature (−)
80 cm
Index of Refraction
1.50
Diameter
80 cm
Focal Points (F)
Virtual Image
Labels
Second Point

Question

1. Images formed by concave lenses are

a. real and inverted.

b. virtual.

c. enlarged.

d. none of the above.

2. What are concave lenses?

a) Thicker from the center than at the edge

b) Thinner from the center than at the edge

c) Thicker from both the positions

d) Thinner from both the positions

3. When will the convex lens give a real image?

a) Beyond optical center

b) Beyond focus

c) Beyond center of curvature

d) Between focus and curvature

4. What is the lens?

a) An image – forming device

b) An image – producing device

c) An image – reflecting device

d) An object – reflecting device

2. What are the two basic types of convex lenses?

3.Can a convex lens produce virtual images?