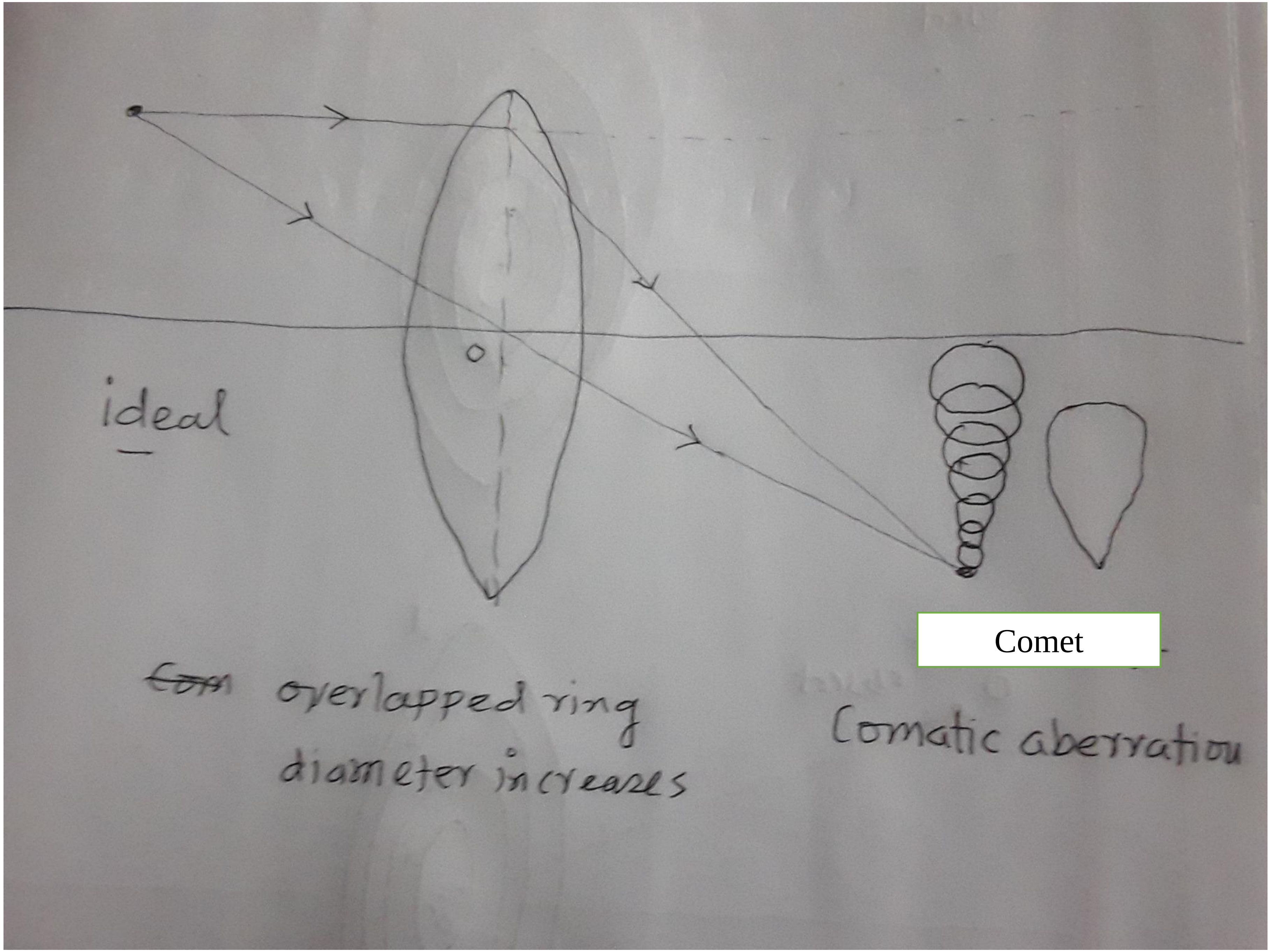
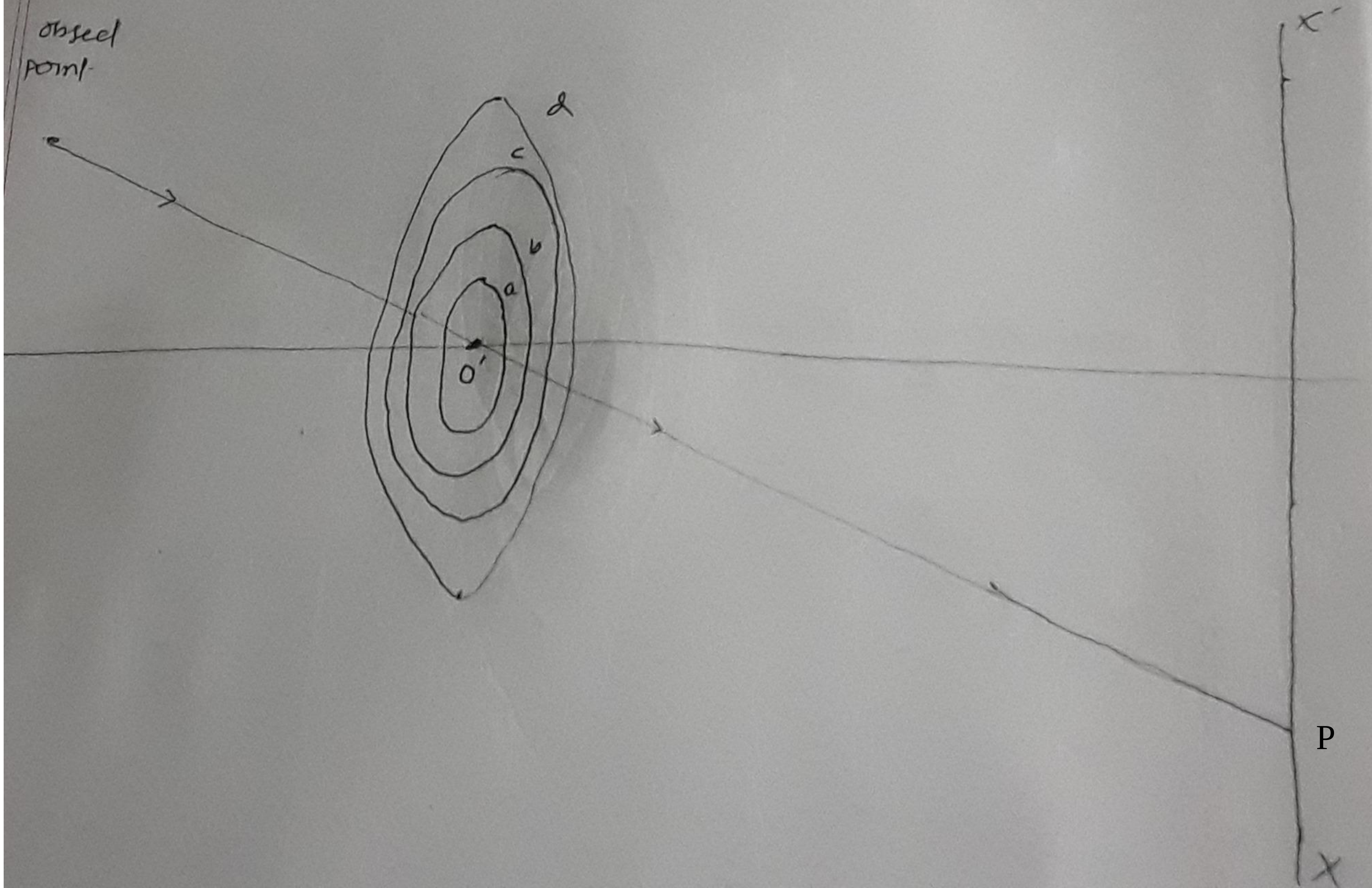
Coma Aberration or comatic aberration

Spherical aberration arises due to point object placed on the axis.

If the object be situated off the axis, the image of such object suffers from aberration known as Coma.

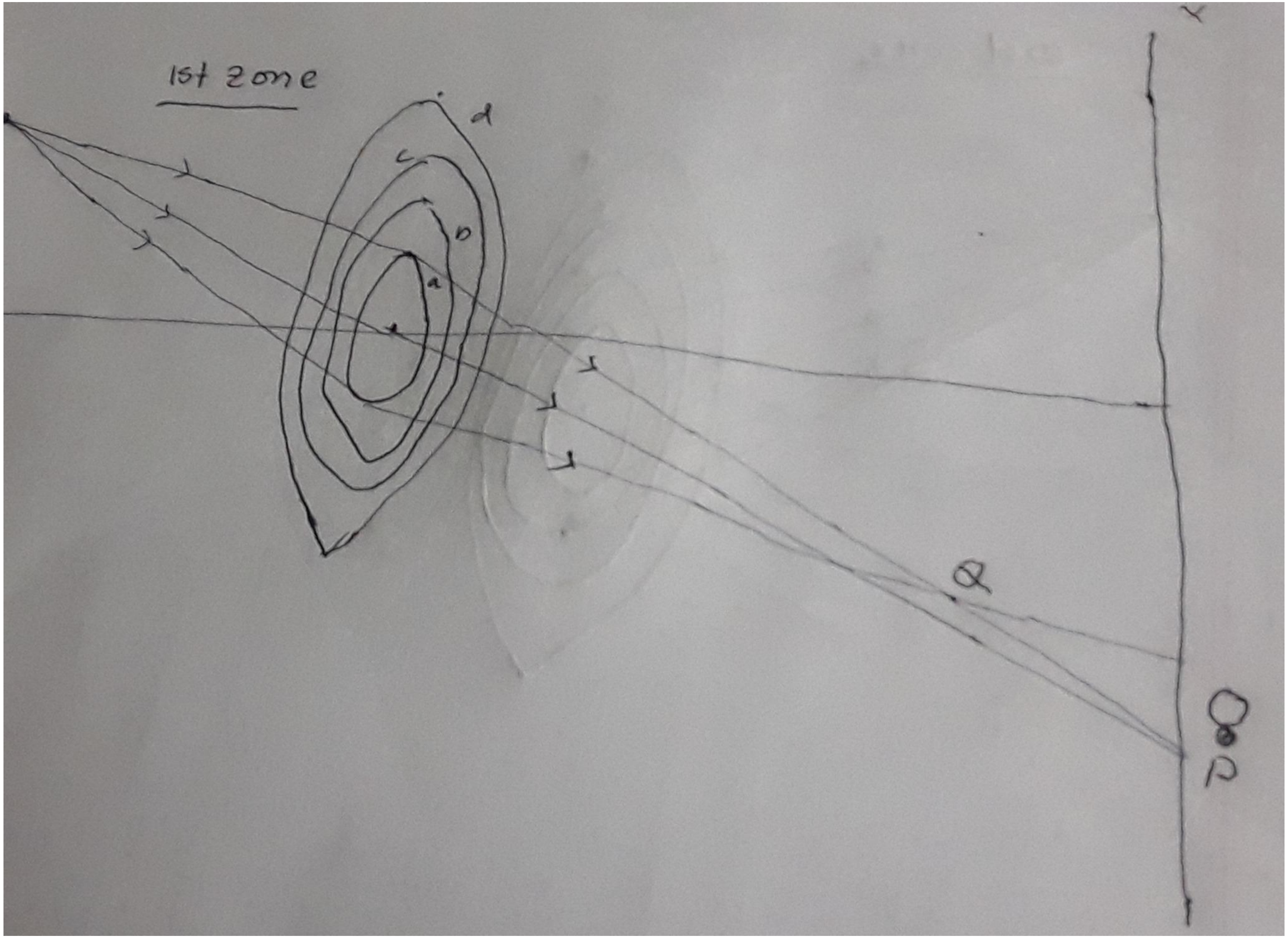
This aberration arises due to different zones of lens. These zones produce different lateral magnifications in images, which are responsible for coma. The coma is illustrated in Fig. 1.


ideal
Comet
~~Com~~ overlapped ring
diameter increases
Comatic aberration

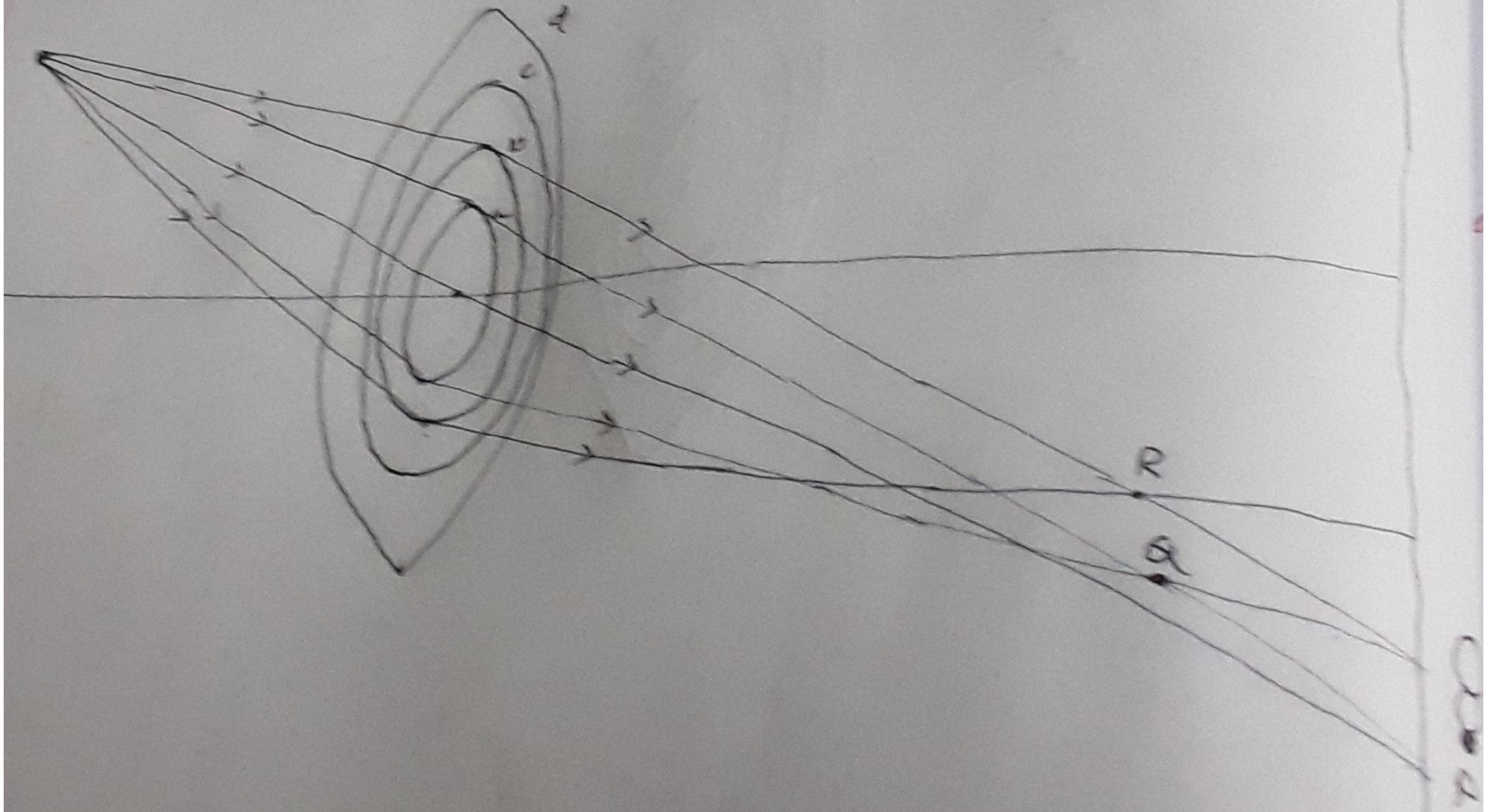


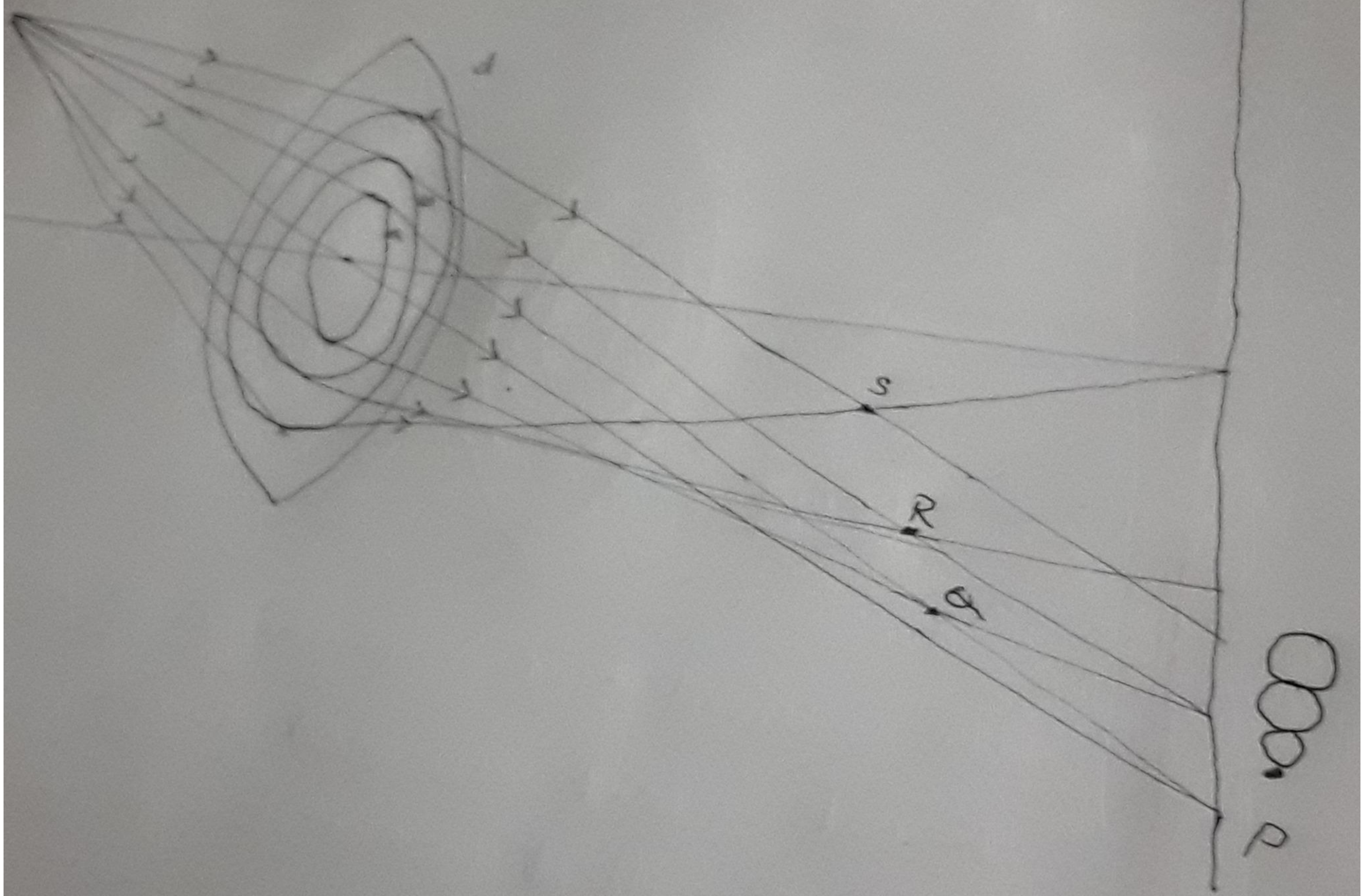
obseed
point
d
c
b
a
O'
X'
P
X

1st zone

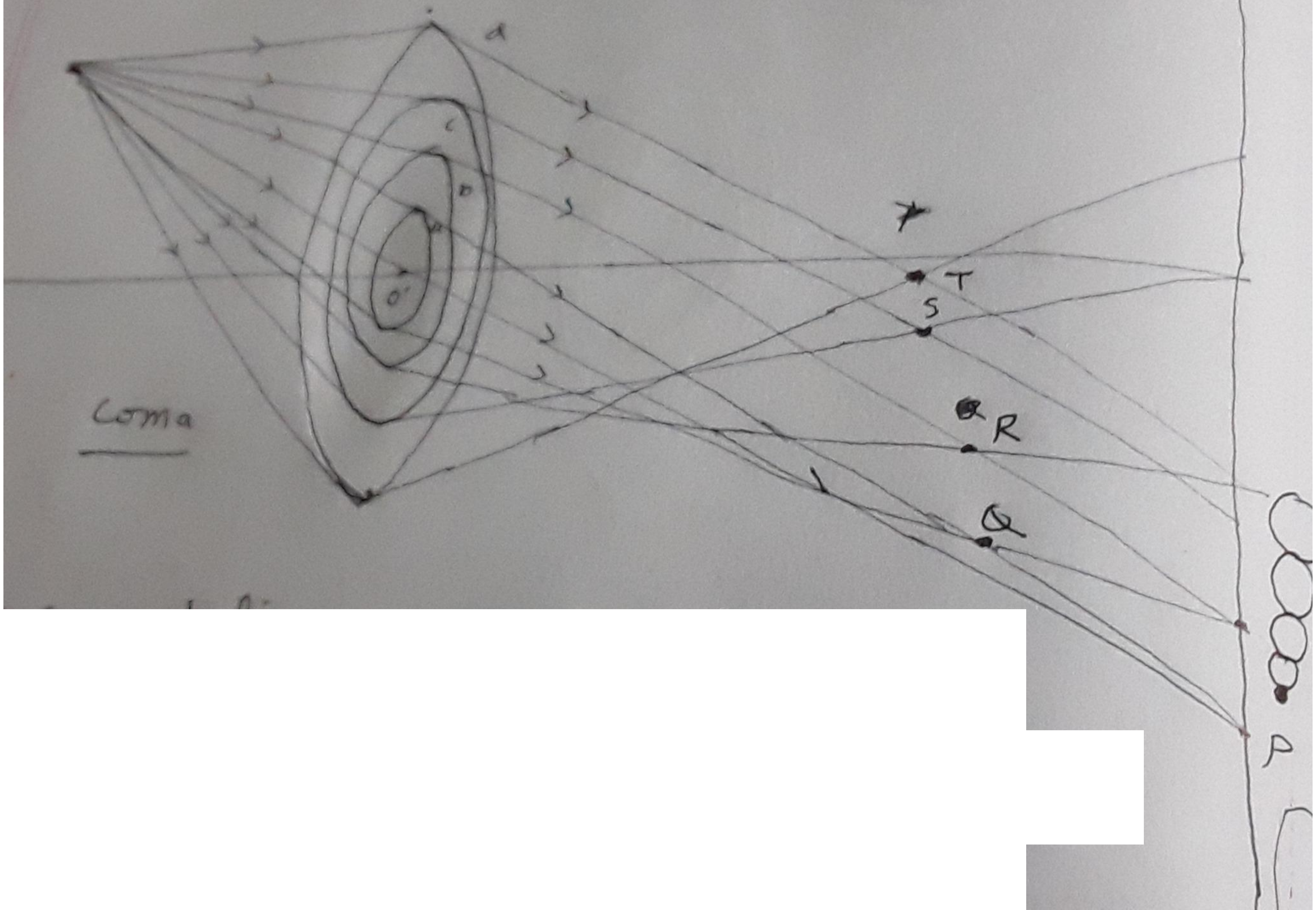


2nd zone




S
R
Q
P

4th zone

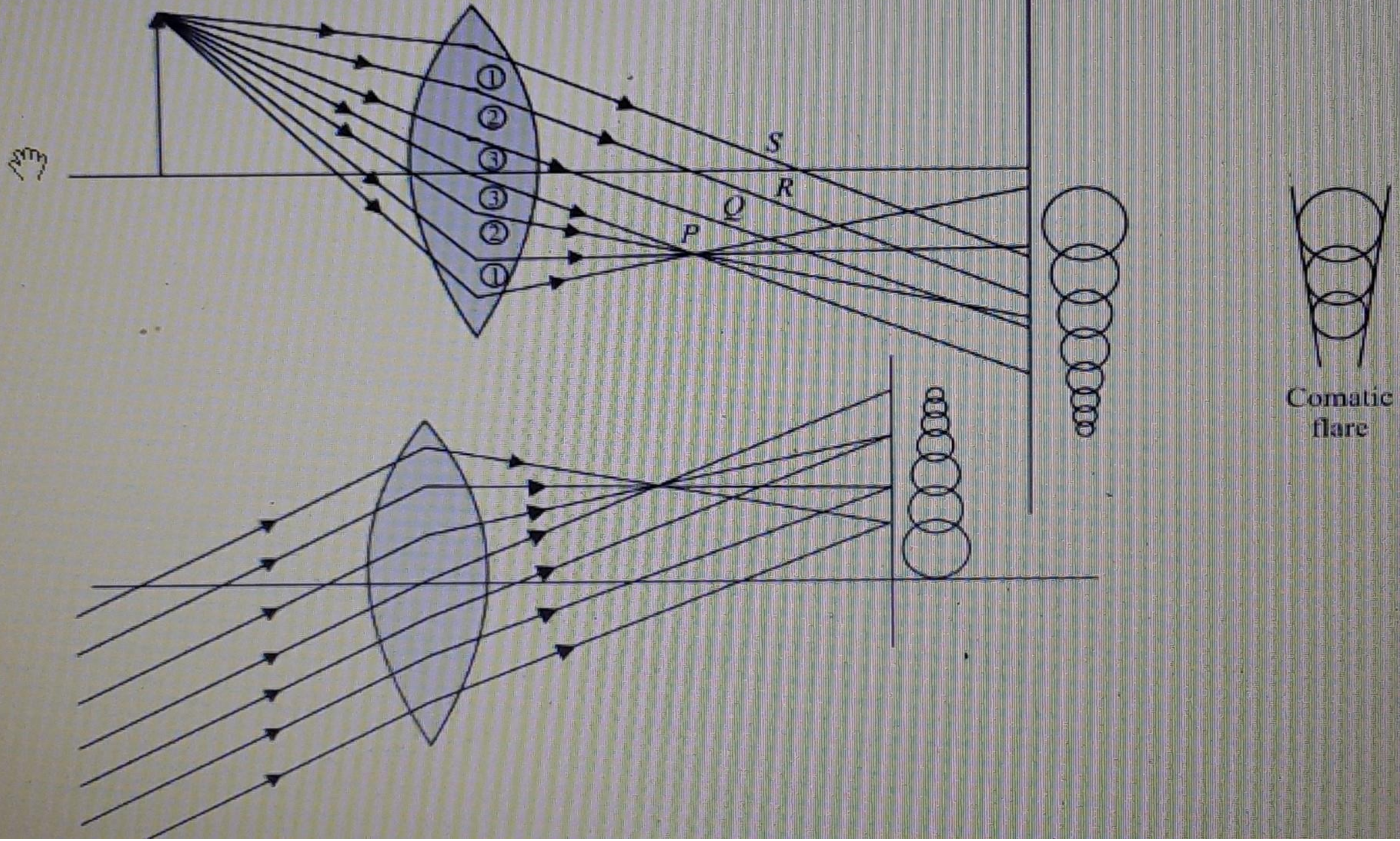


Coma

The comet like appearance of a point object situated away from principal axis is called comatic aberration.

Reason for comatic aberration

The linear magnification produced by different zones of lens is different for a point object situated away from principal axis



1
2
3
3
2
1
S
R
Q
P
Comatic flare

The different zones of the lens are shown as (1, 1), (2, 2), (3, 3), …….. etc. Light rays are incident on the lens after refraction through the zone meet at the screen, off the axis, at different points. For example, the rays passing through (1, 1), (2, 2), (3, 3), ……. Zones focus at points P, Q, R respectively. It is also observed that the rays incident on outer zones after refraction focus nearer to the lens than those of inner zones.

Therefore, the image as the overlapping circular paths of increasing diameter is obtained off the axis. The resultant of these paths is comet-shaped and, hence, named as comatic aberration or coma.

If the magnification of image produced due to outer zones is smaller than the inner zones ($m = \frac{h_2}{h_1} = \frac{I}{O}$), the coma is known as negative.

If the magnification produced due to outer zones is greater than the inner zones, the coma is said to be positive.

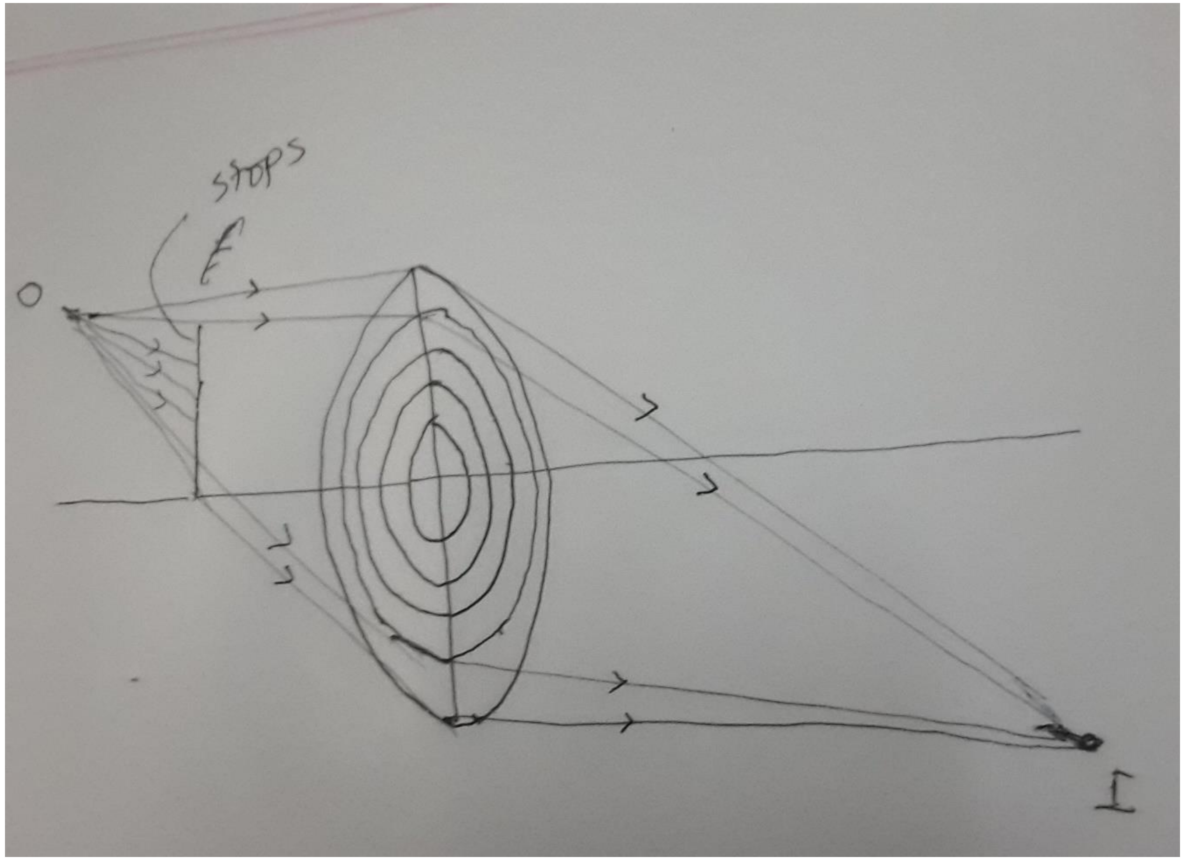
It is also seen that a lens corrected for coma will not be completely free from spherical aberration and that corrected for spherical aberration will not be free from coma.

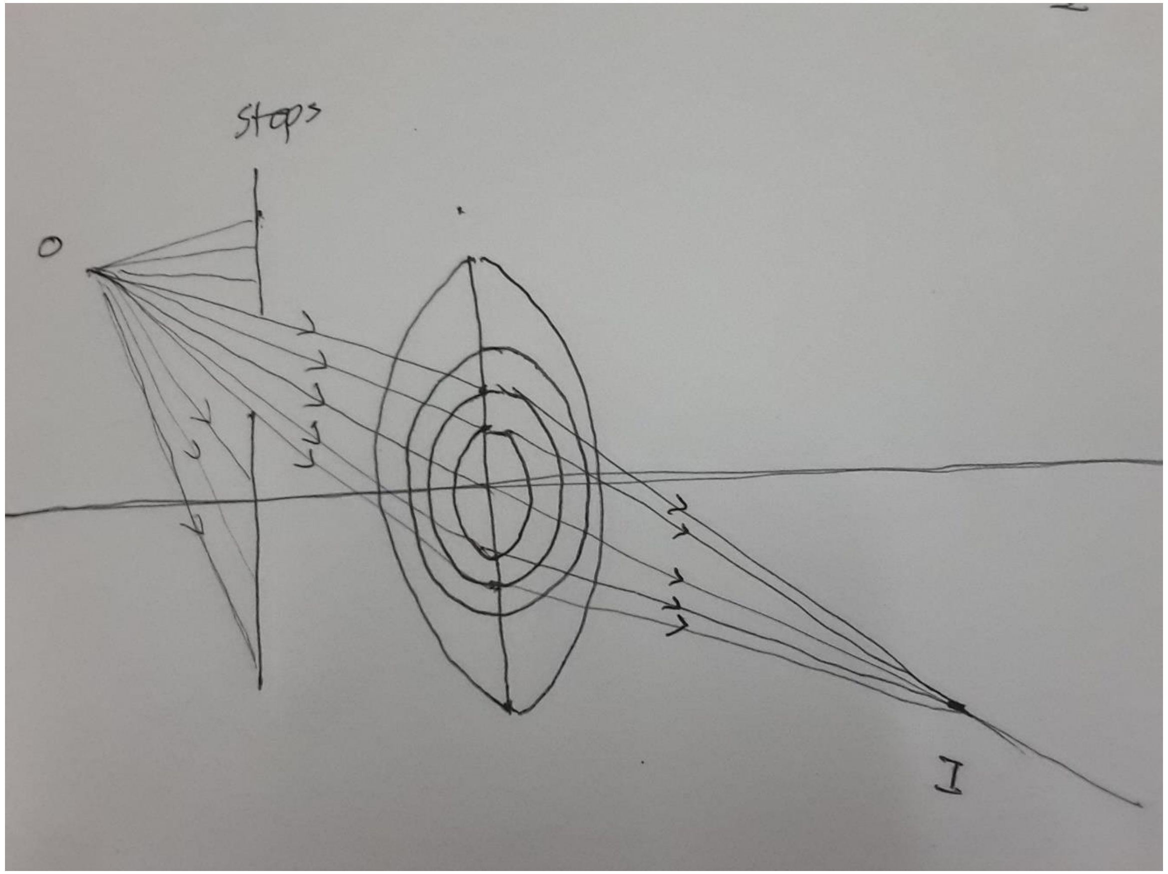
Difference between spherical aberration and coma

Sl. No.	Spherical aberration	Coma
1	Spherical aberration arises due to the object situated on the axis.	Coma arises due to the object situated off the axis.
2	It arises due to different zones of the lens having different powers.	It arises due to different zones of lens having different magnifying powers.
3	In spherical aberration, the image is circles of varying diameter.	In comatic aberration, the image is the patches of overlapped circles perpendicular to the axis. The diameters of these circles decrease as we go away from the axis.

Removal of coma

(i) **By using stops**: The coma can be minimized by using proper stops in front of the lens towards the object side as in spherical aberration.

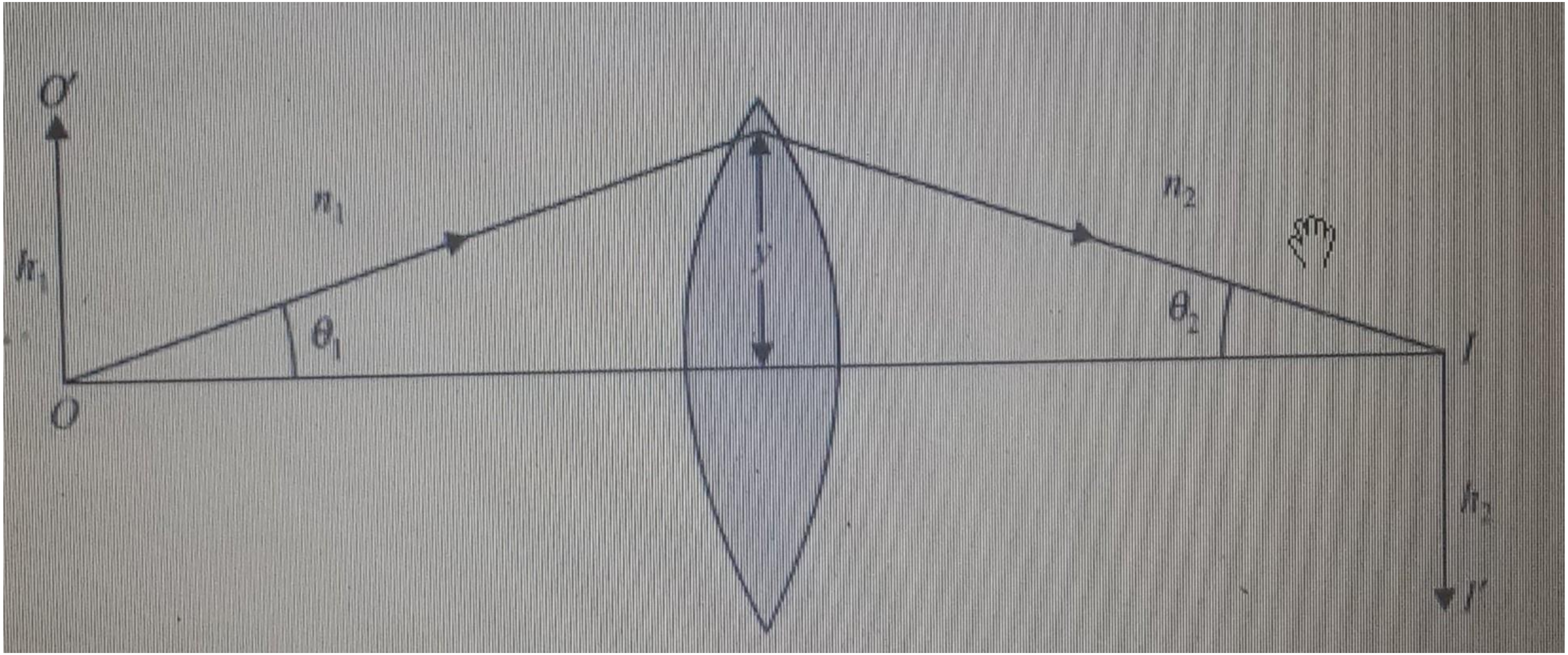




Removal of coma

(ii) **Abbe's sine condition**: The coma arises due to the variation of lateral magnification for the rays passing through the different zones of the lens. Therefore, to minimize coma, the lens should be so designed that the lateral magnification (h_2/h_1) is the same for all zones (Fig. 1).

From Abbe's sine condition $n_1 h_1 sin\theta_1 = n_2 h_2 sin\theta_2$



Where n_1, h_1, $sin\theta_1$ are the refractive index, height of the object and slope angle of the incident rays with the axis and n_2, h_2, $sin\theta_2$ are the corresponding values in image side.

Therefore, from above equation

$$\frac{n_1 sin\theta_1}{n_2 sin\theta_2} = \frac{h_2}{h_1} = \text{constant}$$

If the system (lens) is situated in air, then ($n_1 = n_2$)

$$\frac{sin\theta_1}{sin\theta_2} = \text{constant}$$

For distant object ($u \rightarrow \infty$) and $sin\theta_1 \infty y$ (where y is the height of the ray), then the condition for no coma

$$\frac{y}{sin\theta_2} = \text{constant}$$

This condition may be satisfied for a pair of conjugate points only. The lens that satisfies the above condition is called planatic lens.