

Understanding Reflection From Spherical Mirrors

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UNDERSTANDING POSITION & MAGNIFICATION OF IMAGE IN SPHERICAL MIRRORS

Laws of reflection:

- The angle formed by an incident is equal to the angle formed by reflected ray.
- The incident ray, the normal ray to the mirror at the point of incident and the reflected ray, all lie in the same plane.



OD - incident ray
OC - normal
DC - reflected ray
OAB - reflecting surface

$$\angle ODE = \angle ODC = i = r$$

Spherical mirrors:

Spherical mirrors are the mirrors whose reflecting surfaces are curved like a hollow sphere. Spherical mirrors are of two types, they are Concave mirrors and Convex mirrors. Concave have reflecting surfaces curved inwards, Convex have reflecting surface curved outwards.



How do you define focus or focal point?

Focal point is the position where rays parallel to principal axis converge or appear to be converged. In case of convex mirrors rays appear to be converged. In case of concave mirrors they actually converge. In case of convex mirrors focal point is virtual. In case of concave mirrors the focal point is real.

Derivation of R=2f formula of mirror.



as per law of reflection $i = r$ since $i = \alpha$, $r = \alpha$

$$\theta = 2\alpha$$

for an narrow beam $PC \approx h$ for a small arc, length of arc \approx length of chord.



$$\theta = \frac{h}{R}$$

$$\text{In } \triangle PCF; \theta = \frac{h}{f} \quad \text{In } \triangle PFC - \theta = 2\alpha \quad \text{--- (1)}$$

$$\text{In } \triangle PCF; \alpha = \frac{h}{R} \quad \text{--- (2)}$$

$$\text{Combine (1) \& (2)}$$

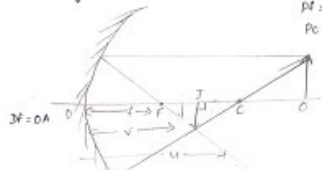
$$\frac{h}{f} = 2 \times \frac{h}{R} \quad \text{or } f = \frac{R}{2}$$

provided $h \ll R$ i.e. beam is narrow.

To find position of image in spherical mirror, for image formation minimum 2 rays are required.

$$P1: f = \frac{R}{2}$$

$$P2: v = u$$



v - is the distance of image from mirror
u - is the distance of object from mirror.

$$\triangle AOC \cong \triangle B'IC \quad \frac{CI}{OC} = \frac{BA}{OA} \quad \text{--- (1) Property of similar } \Delta.$$

$$\triangle DPC \cong \triangle DFI \quad \frac{FI}{FI} = \frac{DB}{BI} = \frac{OA}{BI}$$

$$\frac{FI}{PF} = \frac{BI}{OA} \quad \text{--- (2)}$$

Combining (1) & (2)

$$\frac{v}{f} = \frac{CI}{OC} = \frac{FI}{PF}$$

$$CI = PC - PI$$

$$= R - v$$

$$\frac{R-v}{f} \rightarrow \frac{u}{f}$$

$$\begin{aligned} 2f - vf &= uv - uv - fu + ff \\ -vf &= uv - uv - fu + fu \\ uv &= 2fv - fu + fu \\ &= fv + fu \\ \text{divide this equation with } uvf & \\ \frac{uv}{uvf} &= \frac{fv}{uvf} + \frac{fu}{uvf} \\ \frac{1}{f} &= \frac{1}{v} + \frac{1}{u} \end{aligned}$$

formula of spherical mirrors

Cartesian Sign Convention

- All the distances on right of pole are +ve and all the distances on the left of pole are -ve.
- all the heights (above principal axis) are +ve. all the heights (below principal axis) are -ve.

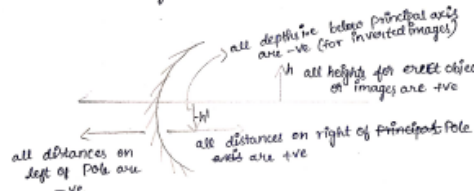
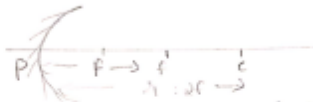


Image formation for object beyond c but not at infinity.



Cartesian Sign Convention.

Sign Convention in geometrical optics.
 i) Object at focal point.



When object is at focal point

$$u = f$$

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

$$\frac{1}{v} = 0$$

$$\frac{1}{f} - \frac{1}{f} = \frac{1}{v} = 0$$

$$\text{or } v = \infty$$

$$u = f (+ve) \quad v = \rightarrow +\infty$$

$$f = (+ve)$$

object is placed between P & f



$$\text{let } f = +10 \text{ cm}$$

$$u = 5 \text{ cm}$$

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

$$\frac{1}{10} = \frac{1}{5} + \frac{1}{v}$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{5}$$

$$= \frac{1-2}{10} = -\frac{1}{10}$$

$$v = -10$$

By using geometry and using algebraic formula with sign convention we get identical results.

Image formation by Concave mirrors
 Case (i) Object at infinity



Characteristics of image:

- * Image is formed at f
- * It is a real image and inverted.

Case (ii) object beyond c but not at infinity.



Characteristics of image:

- * Image is real, inverted
- * Image is formed between F & C.

Case (iii) object at centre



Two rays are required to form an image. one ray will be taken parallel to principal axis, one ray is parallel to principal axis, second ray is radial either it is coming from the centre or passing through the centre.

Characteristics of image:

- Position beyond c on principal axis.
- Image is inverted.
- Image can be obtained on a screen i.e. on real image.
- Image is larger than object.

Case (iv) Object at f.



Two rays

- Parallel to principal axis.
- From radial.

These rays are parallel and meet at form image at infinity.

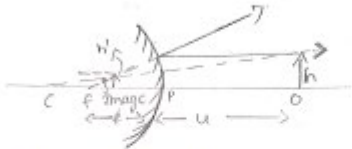
$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

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

$$\frac{1}{v} = 0$$

This is possible when $v \rightarrow \infty$

Image formation by convex mirror
 case: object is in front of mirror.



Characteristic of images:

1. Image is formed behind the mirror.
2. Image is virtual, you can't take it on screen.
3. Image is erect.
4. Image is of reduced size.

Formula for magnification:

for calculating magnification

→ Create a ray diagram to find 'v' for a given u and f

(or)
 use formula $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$
 and $\frac{h'}{h} = \frac{v}{u}$



$$f = \frac{h}{u} \quad \text{--- (1)}$$

$$-f = \frac{h'}{v}$$

$$\text{and } r = -\frac{h'}{v} \quad \text{--- (2)}$$

as per law of reflection $i = r$ --- (3)

Combining (1) & (2) in (3)

$$\frac{h}{u} = -\frac{h'}{v} \Rightarrow \frac{h'}{h} = \frac{-v}{u}$$

lateral magnification is $m = \frac{h'}{h} = \frac{-v}{u}$