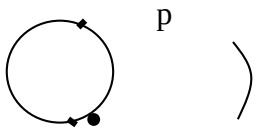
CURVED MIRRORS

Curved mirrors are made by cutting a part of a sphere.



Sphere part of the sphere cut

Types of curved mirrors

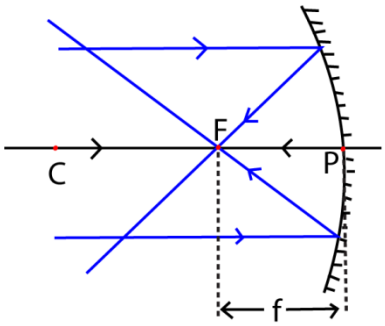
There are two types of curved mirrors namely: Concave mirror and convex mirror

Convex mirror

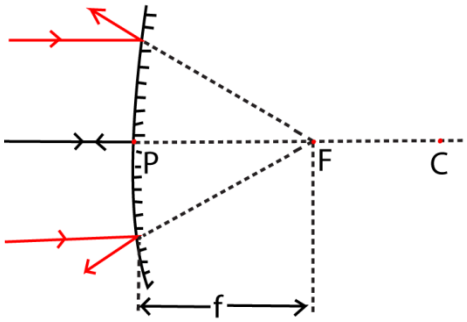
A convex mirror is formed when the outer surface of the part of the sphere is coated with silver.

Concave mirror

A concave mirror is formed when the inner surface of the part of the sphere is coated with silver.



Concave mirror



Convex

Definitions

1. **Centre of curvature C:** it is the centre of the sphere of which the mirror forms part.
2. **Radius of curvature r:** it is the radius of the sphere of which the mirror forms part.
3. **Pole of the mirror:** it is the mid-point (centre) of the mirror surface.
4. **Principal axis CP**: it is the line that passes through the centre of curvature and the pole of the mirror.
5. **Secondary axes:** These are lines parallel to the principal axis of the mirror.
6. **Paraxial rays:** These are rays drawn close and parallel to the principal axis
7. **Marginal rays:** These are parallel rays furthest from the principal axis of the mirror.
8. **(i) Principal focus "F" of a concave mirror:** it is a point on the principal axis where paraxial rays incident on the mirror and parallel to the principal axis converge after reflection by the mirror.

(ii). Principal focus "F" of a convex mirror: it is a point on the principal axis where paraxial rays incident on the mirror and parallel to the principal axis appear to diverge from after reflection by the mirror

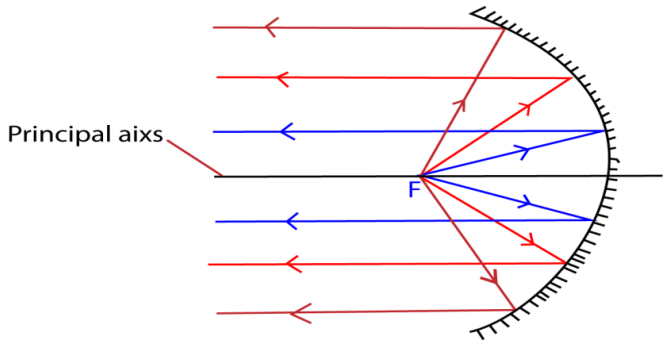
9. **(i) Focal length "f" of a concave mirror:** it is the distance from the pole of the mirror to the point where paraxial rays incident and parallel to the principal axis converge after reflection by the mirror.

   (**ii) Focal length "f" of a convex mirror:** it is the distance from the pole of the mirror to the point where paraxial rays incident and parallel to the principal axis appear to diverge from after reflection by the mirror.

10. **Aperture of the mirror:** it is the length of the mirror surface.

Hyperbolic mirror

These is a type of concave mirror that reflects all the parallel incident beam on to a unique point F, the principal focus of the mirror.



Note that in car headlight and torches, the reflecting surfaces are hyperbolic. When a bulb is placed at the principal focus of reflecting surface, a strong parallel beam of light is obtained. Hyperbolic mirrors are also used in reflecting telescopes.

Geometrical rules for the construction of ray diagrams

The following is a set of rules for easy location of the images formed by spherical Mirrors.

1. Rays parallel to the principal axis are reflected through the principal focus.
2. Rays through the principal focus are reflected parallel to the principal axis.
3. Rays passing through the centre of curvature are reflected back along their own paths.
4. Rays incident to the pole are reflected back, making the same angle with the principal axis.

NOTE:

(i) The normal due to reflection at the mirror surface at any point must pass through the centre of curvature.

(ii) The image position can be located by the intersection of two reflected rays

initially coming from the object.

Real and virtual images

A REAL IMAGE: This is the image formed by the actual intersection of light rays from an object and can be received on the screen.

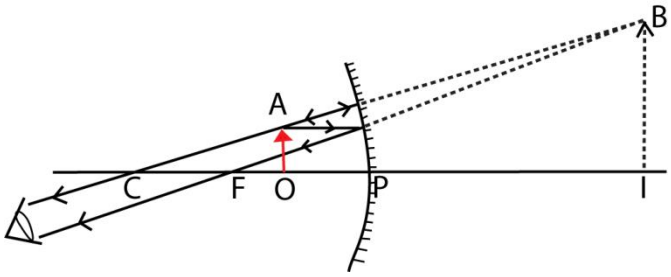
A VIRTUAL IMAGE: This is the image formed by the apparent intersection of light rays and cannot be received on the screen

IMAGES FORMED BY A CONCAVE MIRROR

The nature of the image formed by a concave mirror is either real or virtual depending on the object distance from the mirror as shown below;

Object between F and P the image is

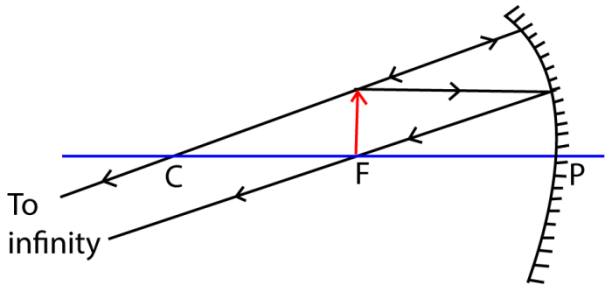
(a) Behind the mirror
(b) Virtual
(c) Erect
(d) Magnified



The property of a concave mirror to form erect, virtual and a magnified image when the object is nearer to the mirror than its focus makes it useful as a shaving mirror and also used by dentists for teeth examination.

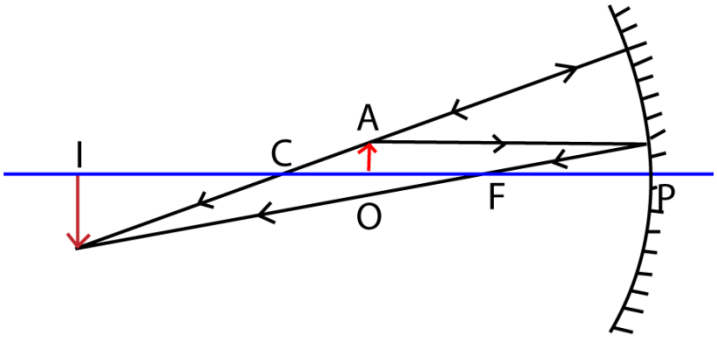
Object at F the image is

(a) at infinity



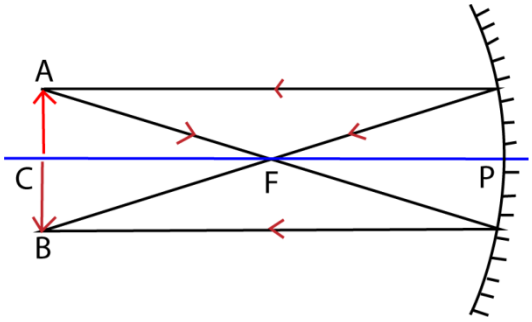
Object between F and C the image is

(a) Beyond C
(b) Real
(c) Inverted
(d) Magnified



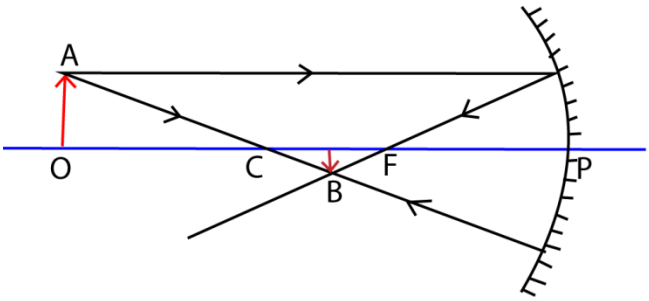
Object at C the image is

(a) At C
(b) Real
(c) Inverted
(d) Same size as the object



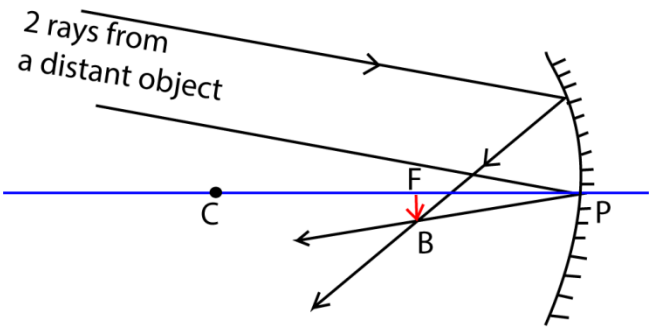
Object beyond C the image is

(a) Between C and F
(b) Real
(c) Inverted
(d) Diminished



Object at infinity the image is

1) At F
2) Real
3) Inverted
4) Diminished



NOTE;

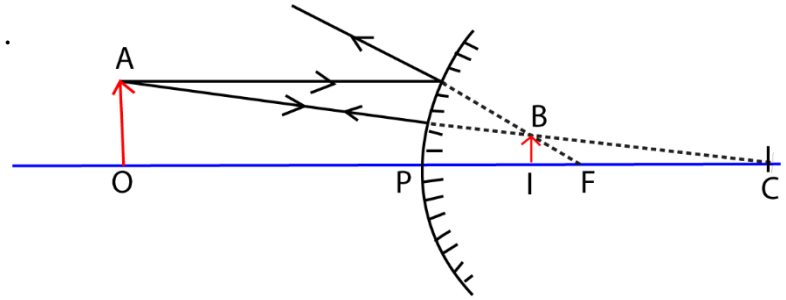
Generally the image of an object in a concave mirror is virtual only when the object is nearer to the mirror than its focus.

Uses of concave mirrors

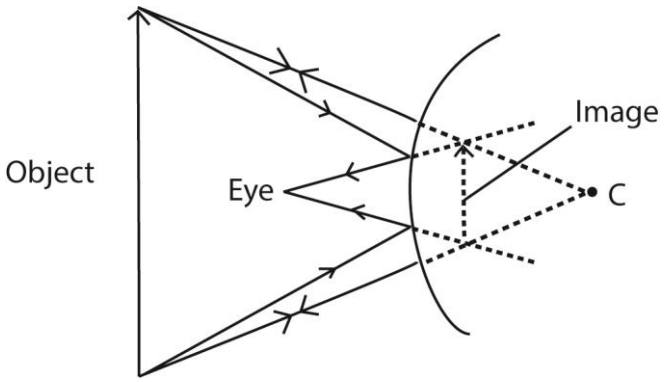
(i) They are used as shaving mirrors.
(ii) They are used by dentists for teeth examination.
(iii) They are used as solar concentrators in solar panels.
(iv) They are used in reflecting telescopes, a device for viewing distant objects
(v) They are used in projectors, a device for showing slides on a screen.

IMAGES FORMED BY A CONVEX MIRROR

The image of an object in a convex mirror is erect, virtual, and diminished in size no matter where the object is situated as shown below



In addition to providing an erect image, convex mirrors have got a wide field of view as illustrated below.



Uses of convex mirrors

(i)They are used as car driving mirrors
(ii)They are used in reflecting telescopes, a device for viewing distant objects

Construction of ray diagrams on graph paper

Step 1: On graph paper draw a central horizontal line (which acts asthe principal axis) with a perpendicular line to act as thecurved mirror,
Step 2: Where distances are given, choose a scale for object size and position.
Step 3: Measure the focal length **F** and radius of curvature **r** from the mirror and mark **C** and **F** as centre of curvatureand principal focus respectively.
Step 4: Draw two of the principal rays to obtain the image,
Step 5: Measure the position and size of the image using the scale.

Linear magnification

Magnification (m) = $\frac{\textbf{height of image } (\mathbf{h^1})}{\textbf{height of object } (\mathbf{h})}$

OR

Magnification (M) = $\frac{\textbf{Image of distance}(\mathbf{v})}{\textbf{object distance } (\mathbf{u})}$

Curved mirror equation

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

f= focal length
u = object distance
v= image distance

Examples on concave mirror

An object is placed (a) 30cm (b) 10cm infront of a concave mirror of focal length 12cm. Find the nature and position of the image formed in each case

(a) u= 30cm f = 12cm

$= \frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{5-2}{60} = \frac{1}{v}$

$= \frac{1}{12} = \frac{1}{30} + \frac{1}{V} \frac{3}{60} = \frac{1}{v}$

$= \frac{1}{12} = \frac{1}{30} + \frac{1}{V} \frac{1}{20} = \frac{1}{V}$

V = 20cm

So the nature of the image is real because the value of v is positive, and magnified because v is larger than u

(b) u =10cm f =12cm

$= \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $= \frac{5-6}{60} = \frac{1}{v}$

$= \frac{1}{12} = \frac{1}{V} + \frac{1}{10}$ $= \frac{1}{60} = \frac{1}{V}$

$\frac{1}{12} - \frac{1}{10} = \frac{1}{V}$

V =-60cm

So the image is virtual because the value of v is negative, and magnified because v is greater than u.

Examples on convex mirror

An object is placed (a) 30cm (b) 10cm in front of a convex mirror of focal length 12cm. Find the nature and position of the image formed in each case,

Solution

(a) f = -12cm (focal length "f" of convex mirror is virtual).

u = 30

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

$= \frac{-1}{12} = \frac{1}{30} + \frac{1}{v}$

$= \frac{-5-2}{60} = \frac{1}{v}$

v = -8.6cm

u =10cm

$\frac{1}{f} = \frac{1}{V} + \frac{1}{10}$

$\frac{-1}{12} - \frac{1}{10} = \frac{1}{v}$

$\frac{-5-6}{60} = \frac{1}{v}$

v= 5.5cm

The images formed by a convex mirror are virtual and diminished

Experiments to measure the focal length of a concave mirror

Method I

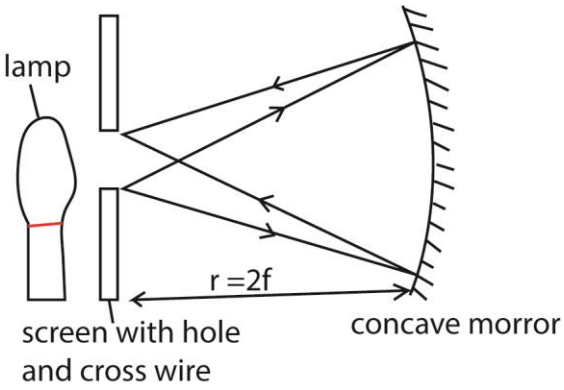
A distant object is focused on the screen.

The distance between the pole of the mirror and the screen is the focal length

Method II

A sharp image of illuminated wire guaze if formed besides the wire guaze in a mirror.

The distance between the wire guaze and the pole of the mirror is twice the focal lenght.

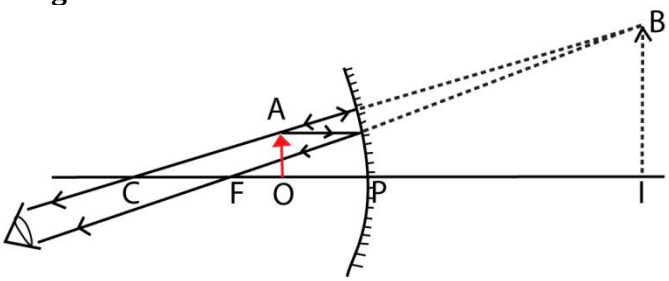


Use of curved mirror

(a) **Shaving mirror**

If the object is placed between the focal point and pole of the concave mirror, a virtual, erect and magnified image is formed. So it is used as magnifying mirror.

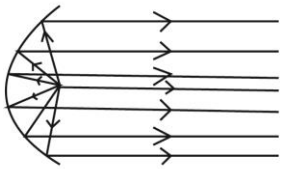
Diagram to be drawn



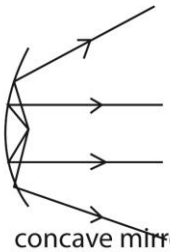
(b) **Reflector**

When a point source of light is placed at the principal focus of a concave mirror, the reflected beam is parallel. So concave mirrors are used as reflectors in torches and car head lamps since when the source is placed at the principal focus a parallel reflected beam is obtained. However, hypebolic mirrors are better because the give a strong reflected beam

Diagram to be drawn



Parabolic mirror reflect
strong beam of light

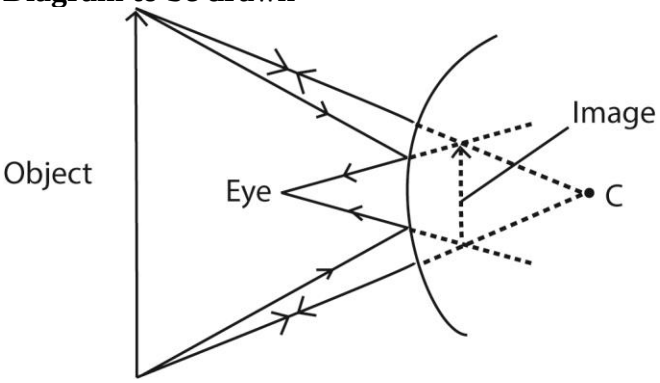


concave mirrors reflect
diminishing beams

(c) Driving mirror

Convex mirrors are used as driving mirrors because they give a wider field of view than plan mirror.

Diagram to be drawn



Telescope

Both convex and concave mirrors are used in reflecting 'telescopes because of their larger aperture as their light energy loses are smaller.

Exercise

Objective questions

1. the focal length of a concave mirror is
   A. distance between the pole of the mirror and focal point
   B. distance between the center of curvature and the pole of the mirror
   C. distance between oject and the mirror
   D. any point on the principle axis.

2. Which of the following information is true about the concave and convex mirrors.

Concave mirror	convex mirror
a) Converges light	diverges light
b) Diverges light	converges light
c) Refracts light	reflects light
d) Has a wide field of view	has a narrow field of view

3. Which one of the following optical divices can be used as soalr concentrator

   A. convex mirror
   B. concave mirror
   C. concave lens
   D. glass prism

4. When an object is placed in front of a concave mirror at a distance less than the focal length of the mirror, the image formed is
   A. Virtual, upright, diminished
   B. Real, upright, magnified
   C. Virtual inverted and magnified
   D. Virtual, upright, magnified

5. Which of the following statements are true abut the action of a curved mirror on rays of light
   A. Rays passing through the focal point are reflected back along the same paths
   B. Rays incident parallel to the principal axis are reflected through the center of curvature
   C. Ray incident to the pole make the same angle with the principal axis after reflection
   D. Rays passing through the centre of curvature are reflected parallel to the principal axis
6. The focal length of a concave mirror is the
   A. distance between the pole of the mirror and the focal point
   B. distance between the center of curvature and the mirror
   C. distance between the object and the image
   D. diameter of the mirror

7. A concave mirror can be used as a shaving mirror because when an object is placed between the focus and the pole, the image formed is
   A. magnified, real and inverted.
   B. diminished, real and inverted.
   C. diminished, virtual and erect.
   D. magnified, virtual and erect.

8. A concave mirror may be used as
   (i) a magnifying mirror.
   (ii) a torch reflector.
   (iii) a driving mirror.
   A. (i) only
   B. (i) and (ii) only.
   C. (ii) and (iii) only.
   D. (iii) only

Answers to objective questions

1	A	2	A	3	B	4	D	5	C	6	A	7	D	8	B

Strucures questions

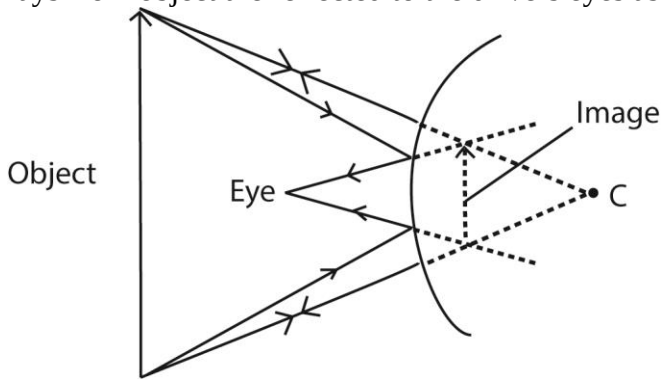
9. An object is placed perpendicular to the principal axis between the principal focus and the centre of curvature of a concave mirror.
   (a) Sketch a ray diagram to show the formation of an image of the object
   (b) State the properties of image formed.
   - İmage formed behind the mirror
   - Virtual
   - Magnified/larger than object
   - Upright/erect

10. (a) Explain the term virtual image as applied to optic

A virtual image formed by apparent intersection of rays from an object that cannot be formed on the screen

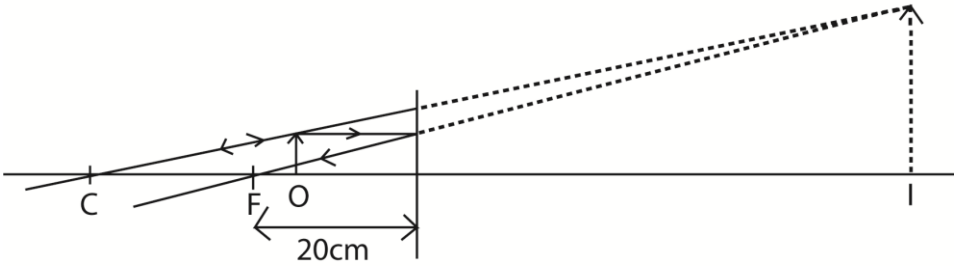
(b) With the aid of a ray diagram, explain why a convex mirror is used as a driving mirror.

A convex mirror forms diminished upright images from a wide field of view; The rays from object are reflected to the drivers eyes as shown below



- has wide field of view
- forms upright mage

(c) An obect is placed 15cm infront of a concave mirror. An upright image of magnification 4 is procuded. By graphical method determine the



vertical scale 1cm represents 5cm
horizontal scale 1cm represent 5cm
focal lenght = 4 x 5 = 20cm

(i) Nature of the image
Virtual and magnified

(ii) Forcal length of the mirror
Focal length = 4 x 5 = 50cm

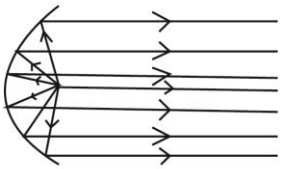
(iii) Distance of the image from the mirror
12 x 5 = 60cm

(d) Name two application of a concave mirror

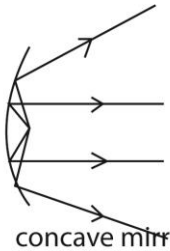
- Shaving mirror
- İn telescope

- İn projector lamp

11. (a) Define the following terms as applied to curved mirrors
    (i) Center of curvature
    Center of curvature is the center of the sphere of which the mirror forms part
    (ii) Principle axis
    Principle axis is the line passing through the pole of the mirror and centre of curvature.
    (b) Explain with the aid of a diagram, why a parabolic mirror is preferred to concave mirror as a car head lamp.
    Parabolic mirrors form strong reflected beam when the bulb is placed at the principal axis while the concave mirror reflects a dull beam.

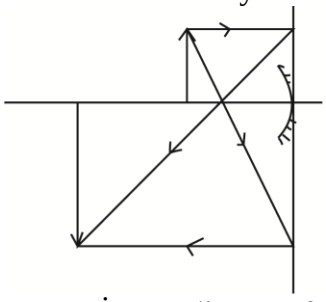


Parabolic mirror reflect strong beam of light



concave mirrors reflect diminishing beams

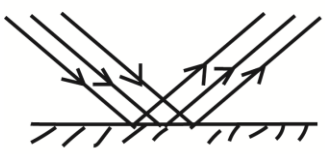
(c) An object of height 5cm is placed 15cm in front og a concave mirror of radius of carvature 20cm. By scale drawing Find the



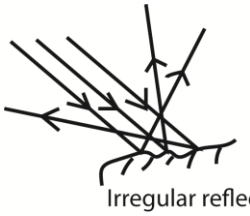
scale
vertical scale 1cm:2.5cm
Horizontal scale: 1cm:5cm
image distance = 6cm x 5 = 30cm
image height= 4cm x 2.5 = 10cm

(i) İmage distance from the mirror
30cm
(ii) Height of the image
10cm

(d) (i) With the aid of a ray diagrams explain how regular and diffuse reflections are produced
In regular reflection parallel incident rays are reflected as parallel rays on smooth surface while in diffuse reflection parallel incident rays are scattered after reflection on rough surface



Regular reflection



Irregular reflection

(ii) state the characteristics of images formed by plane mirrors.

- Virtual
- Erect/upright
- Laterally inverted
- Formed behing the mirror
- Same size as the object
- İmage distance = object distance

12. (a) (i) What is a virtial image

A virtual image is an image formed by apparent intersection of light rays from an object and cannot be formed on a screen

(ii) Under what conditions does a concave mirror form a virtual image

When object is paced between the pole of the mirror and principal focus.

(b) Describe how a focal length of concave mirror can be detemined

Method I

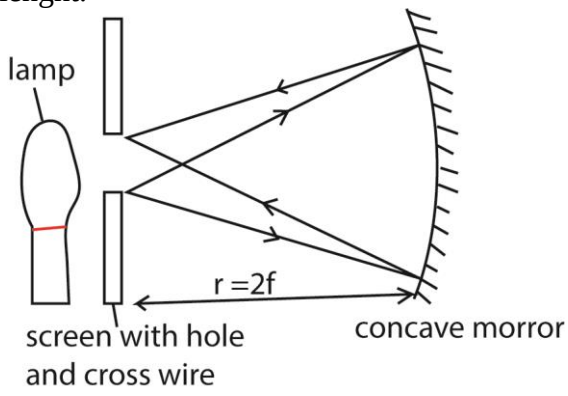
A distant object is focused on the screen.

The distance between the pole of the mirror and the screen is the focal length

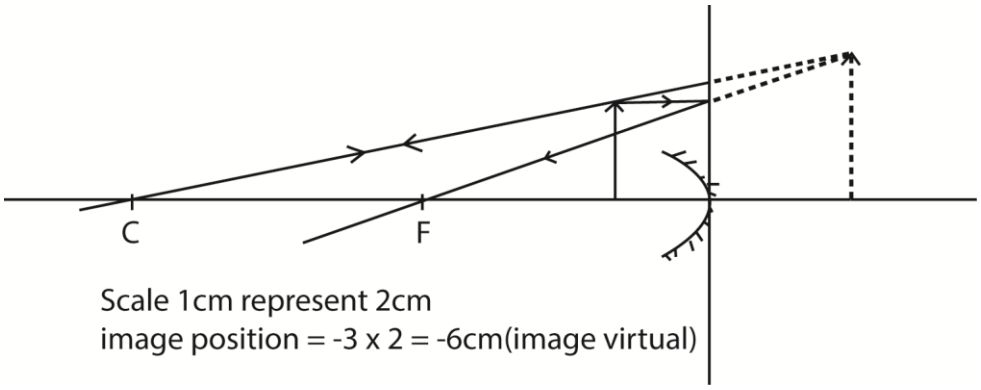
Method II

A sharp image of illuminated wire guaze if formed besides the wire guaze in a mirror.

The distance between the wire guaze and the pole of the mirror is twice the focal lenght.

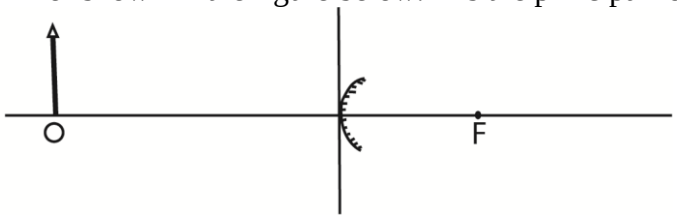


13. An object 4cm tall is placed 4cm in a front of concave mirror of focal lenght 12cm. By graphical construction, find the position and nature of the image formed. (5marks)

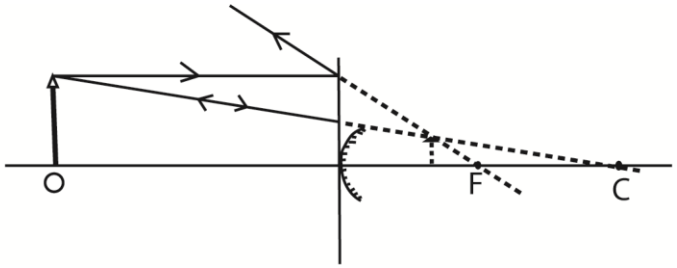


The image is upright, magnified and located behind the mirror

14. (a) Draw a ray diagram to show the formation of an image of an object O placed in front of a convex mirror shown in the figure below. F is the principal focus of the mirror.



Solution



(c) State two applications of convex mirror
- driving mirror
- reflecting periscope