SC5102A

Reflection in Curved Mirrors

Duration: 90 minutes

Grade: IX

This module (Section 7 and Section 8) has been developed based on the suggestions given by Mr. Sengode Tevan (Science TGT, Kamban GHSS, Nettapakkam) as per his insights while teaching students of grades VIII and IX of Udhavi Karangal Children Home on 8th June 2019 and 15th June 2019.

1. Objective

The objective of this module is to guide the students to do the following:

a) Observe how the direction of the incident ray (passing through focus, running parallel to the principal axis, passing through centre of curvature) affects the direction of the reflected ray.
b) Apply the laws of reflection to verify the above findings.

2. Learning Outcomes

After the completion of this module, the students will be able to do the following:

a) Apply the laws of reflection to curved mirrors.
b) Draw ray diagrams for different types of incident rays.

3. Prerequisites

Before commencing with this module, the students should be able to do the following:

a) Apply the laws of reflection to plane mirrors

4. Materials Required

The materials mentioned below will be required to perform the experiment. The quantities of these materials have been suggested assuming that the strength of the class is 30.

S. No.	Material required	Specifications	Quantity	Cost
1	Reflector sheet	Ones used for cars	5 square feet	INR 125
2	Cellophane-tape core	Bendable	2	
3	Toothpaste box	-	6	
4	LED	15	1.5 INR/piece	
5	Protractor	30		
6	PVC tape	1	10 INR	
7	Ruler	30 cm	30	

5. Note to the Teacher

This teaching module consists of three parts:

i) Introductory discussion on curved mirrors (Section 7)
ii Experimental visualization of rules for drawing ray diagrams (Section 8)
iii) Applying and verifying the laws of reflection in the case of curved mirrors.

It is preferable that the introduction to the different types of curved mirrors is done in the class before the introduction of ray diagrams.

The first part involves a discussion between the teacher and the students. The other two parts are structured based on the teaching approach employing the strategy of "I Do, We Do, You Do". The teacher demonstrates the "I Do" part, while the students observe. After this, the "We do" part, which has a similar activity in a slightly different context or with an added difficulty, is done by the teacher along with the students. In the "You Do" part, again with an added element of difficulty, the students perform the activity on their own. During the course of the final "You Do" part, the teacher should provide minimal instructions to the students and, instead, focus on clarifying the doubts faced by the students and correcting their errors. The teacher should instruct the students to draw reflected rays based on their own observations and not rely on what they got to know from the teacher's demonstration.

The reflecting surface, made of a reflector sheet, is pasted onto a curved surface, such as a section of a cellophane-tape core. The reflectance of the reflector sheet, i.e., the percentage of the incident light that it reflects, will not be as high as a normal mirror. It is also common for the surface to get pitted easily. Hence, the rules of ray diagrams may only be visualized as an approximation through the experiments.

Similarly, the laws of reflection for curved mirrors can only be verified approximately, owing to the thickness of the incident beam and the imperfection of the reflecting surface, causing the reflected beam to appear diverging. In such cases, the center point of both the incident beam and the reflected beam can be taken as a close approximation in order to mark the respective rays.

Student worksheets are provided in Annexure 1. An assessment sheet has also been provided in Annexure 2 to assess the understanding of the students. The procedure to make a simple curved mirror has been shown in Annexure 3.

6. Indicators of a Model Science Classroom

A model science classroom has the following elements: science skills, a classroom culture, and a connection to life around the students. This year, we will be focusing on the following specific elements:

1. Science skills:
   The students will understand, at their level, the following elements of the scientific method: generation of a hypothesis, experimentation, observation, analysis, and inference.
2. Classroom conducive for learning science:
   Self-motivation, self-awareness, working in a team, and social/civic awareness and consciousness are key qualities for learning science. The students should be allowed to interact with each other to improve their communication skills through peer-learning.
3. Connection with life around:
   The students should be able to learn and apply the concepts in simple real-life situations.
4. Removal of gaps in learning:
   The gaps in numeracy, literacy, and conceptual understanding of science should be addressed.

This module attempts to achieve the following indicators of a model science classroom.

Classroom Element	Specific Type	Teacher's Actions	Students' Actions
Science skills	Observation	The teacher should demonstrates how to position the incident ray on a chart.	The students should position the incident ray as per the teacher's instructions and observe the reflected ray.
Science skills	Apply	The teacher should demonstrate how a normal is drawn for a curved mirror surface and also show how the laws of reflection are to be applied to curved mirrors.	The students should draw normals at different points of incidence on the surface and apply the laws of reflection to curved mirrors.
Science skills	Analysis	The teacher should demonstrate how a protractor is to be placed to measure the angle of incidence and the angle of reflection. The teacher must guide the students in verifying whether the laws of reflection are obeyed or not.	The students should measure the angles of incidence and the angles of reflection for different incident and reflected rays. They should verify whether a curved mirror obeys the laws of reflection or not.

7. Discussion on Curved Mirrors and Associated Terminologies

1. The teacher can start a discussion relating to plane mirrors. The teacher should draw the symbol of a plane mirror on the blackboard and depict the difference between the polished surface and the rough surface of the plane mirror by using the appropriate symbol.

2. Now, the teacher should attempt to illustrate that if a plane mirror is slightly pushed at the center, its polished surface curves in; and if it is pulled at the center, its polished surface curves out (as shown in Fig. 1).

3. After the students are familiarized with the shapes of concave and convex mirrors, the teacher can illustrate how concave and convex mirrors are formed by drawing two circles—representing two spheres—with one having the inner surface polished and the other having the outer surface polished.

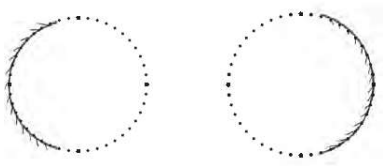


Fig 1. Illustrating Convex and Concave Mirrors as Sections of a Spherical Mirror

4. The teacher should illustrate the removal of the section of the sphere (indicated by dotted lines) having its inner surface polished and elicit the name of this type of mirror (Concave Mirror) from the students. Following this, the removal of the section of the sphere (indicated

by dotted lines) having its outer surface polished should be illustrated and the name of this type of mirror (Convex Mirror) should be elicited from the students.

5. Now, the teacher should introduce the following terminologies associated with curved mirrors as they are defined in the textbooks of grades VIII and IX:.

A. Pole (P)

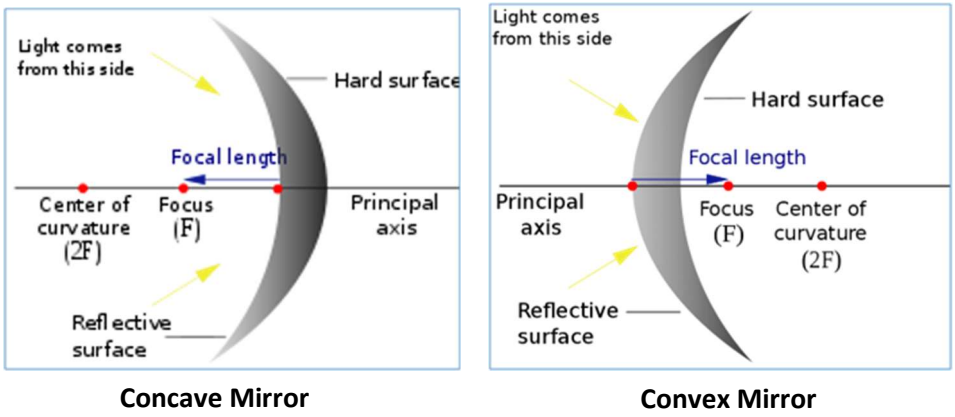
B. Center of Curvature(C)

C. Focus (F)

D. Principal Axis

E. Radius of Curvature (R)

F. Focal Length



Concave Mirror **Convex Mirror**

Fig 2. Terminologies associated with Concave and Convex mirrors

6. The teacher can introduce the aforementioned terminologies with reference to the circle drawn on the blackboard, as the mirror section is part of a circular section (spherical, cylindrical). For example, things such as "the center of curvature is the center of the sphere of which the mirror is a part"; "the radius of curvature is the radius of the sphere of which the mirror is part" can be explained. The relationship between the radius of curvature and the focal length should also be addressed.

8. Reflection by Curved Mirrors

Objective

The objective of this activity is to understand how light is reflected for different orientations of the incident ray (passing through the focus, running parallel to the principal axis, passing through the centre of curvature).

Observables

i) Direction of reflected ray.

Procedure

1. Divide the students in groups of four of five. Distribute a curved mirror surface, a light source having a single slit, and a sheet of paper having the outline of the mirror and all the positions, F, C, P, and the Principal axis marked on them to each group. The direction of the incident ray should also be marked.

"I Do"

2. Now, demonstrate how the light source should be positioned so that the incident ray is parallel to the principal axis on a chart fixed to the wall as shown in figure 3

Fig 3. Demonstration of incident ray parallel to principal axis reflected through focus

3. Make the students observe the direction at which the incident ray runs parallel to the principal axis and the position as well as the direction of the reflected ray (i.e., the reflected ray passes through the focus).

4. Ask the students about the direction of the reflected ray and elicit from them that the incident ray running parallel to the principal axis passes through the focus (F).

We Do

(At this juncture, the students should have an idea of the activity that is going to be performed—observing the direction of the reflected ray for a given incident ray.)

5. Position the incident ray on the chart and ask the students to position the incident ray on their sheets so that the incident ray: i) passes through the focus; ii) passes through the centre of curvature.

6. Let the students come up with their observations regarding the direction of the reflected rays for each orientation of the incident ray.

Pose the question "If the incident ray is parallel to the principal axis, will the reflected ray pass through the focus (F)?" and allow the students to answer.

7. Demonstrate on the chart that the incident ray running parallel to the principal axis appears to come from focus.

8. Repeat steps 6 and 7 for other orientations of the incident ray: i) passing through the focus; ii) passing through the center of curvature; iii) incident at the pole. Let the students infer the direction of the reflected ray.

"You Do"

9. Move around the class and ask each group of students to observe and explain the following: i) the direction of the reflected ray for an incident ray coinciding with the principal axis; ii) the light ray incident at the pole making an angle with the principal axis.

10. Ask one member of each group to explain the direction of the reflected ray for each of the following orientations of the incident ray: i) incident ray running parallel to principal

axis; ii) incident ray passing through the focus; iii) incident ray passing through the center of curvature; iv) incident ray coinciding with the principal axis.

9. Verifying the Laws of Reflection for Curved Mirrors

Objective

The objective of this exercise is to verify the laws of reflection for curved mirrors.

Observables

a. Angle of incidence
b. Angle of reflection
c. Normal

Procedure

1. Ask the students why an incident ray running parallel to the principal axis passes through the focus. Make the students recall the laws of reflection for plane mirrors. Invite a student to illustrate the laws of reflection for plane mirror on the blackboard. Invite other students to suggest corrections if required.
2. Once the laws of reflection for plane mirror is illustrated, ask whether the laws of reflection are applicable to curved mirrors. Invite answers for the question from the students. Let the students explain why the laws of reflection can/cannot be applied to curved mirrors.
3. Elicit responses from the students regarding how it can be checked whether the laws of reflection are applicable to plane mirrors or not.
4. The students may face confusion while drawing a normal for curved surfaces. Explain that the line joining the center of curvature and the point of incidence (i.e., the radius of curvature) is the normal at the point of incidence.

"I Do"

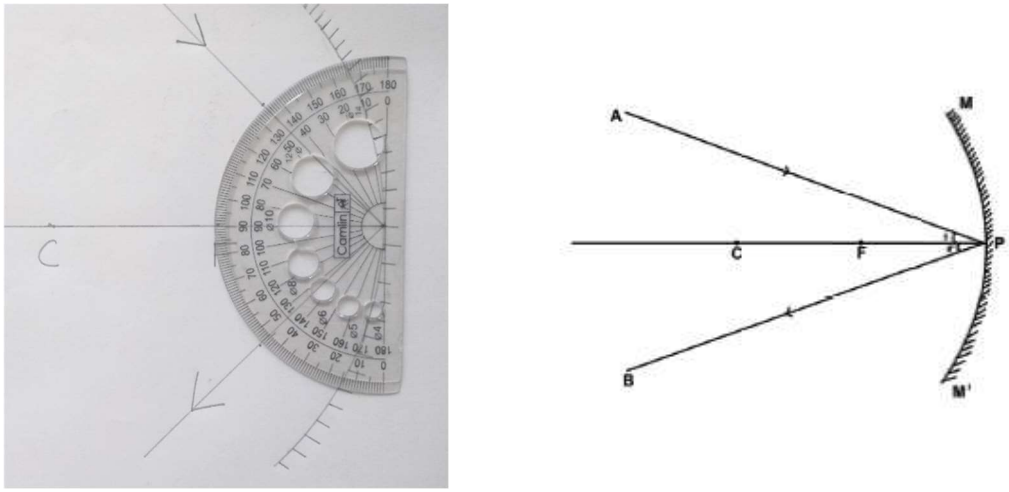
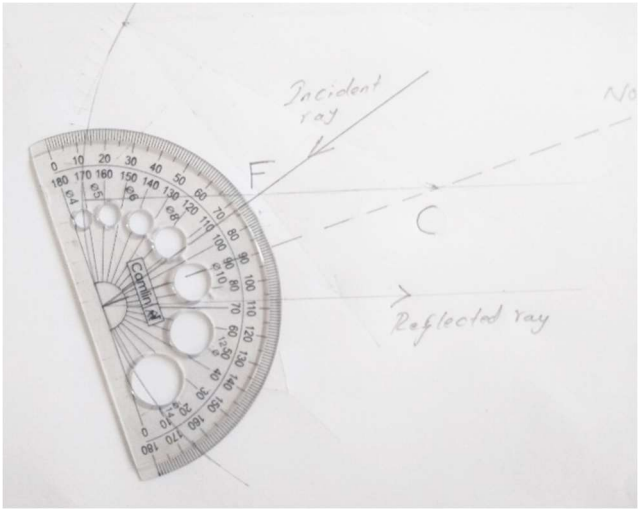


Fig. 4. Applying the laws of Reflection for a Light Ray Incident at the Pole

5. Position the incident ray in a manner that it touches the pole making an angle with the principal axis. Restate how a normal can be drawn for curved mirrors and ask the students what would be the normal for a light ray incident at the pole (Fig. 4).
6. Mark the incident rays and the reflected rays.
7. Illustrate how the principal axis becomes the normal for the above cases and place the protractor in such a manner that the 90° line coincides with the normal (the principal axis in this case).
8. Now, show how the angle of incidence and the angle of reflection can be measured on either side of the normal.
9. Invite a few students to observe the chart.

"We Do"

10. The teacher should ask the students to do the activity simultaneously, while the teacher demonstrates it herself on the board.
11. Position the incident ray parallel to the principal axis and mark the incident ray and the reflected ray.
12. Ask the students to verify the laws of reflection for this case. Invite the students to respond and ask how a normal can be drawn.
13. Explain that a normal is drawn by joining the point of incidence and the center of curvature. Demonstrate how the angle of incidence and the angle of reflection are measured by aligning the 90° line of the protractor with the normal.
14. Ask the students whether the laws of reflection are verified or not. Clarify the doubts of the students.



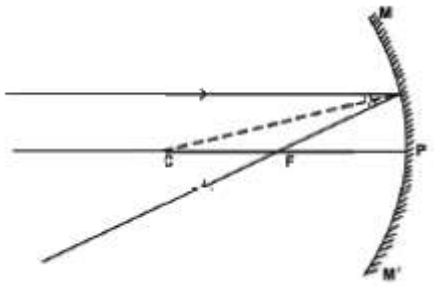


Fig. 5. Verifying the Laws of Reflection for a Light Ray Passing Through the Focus

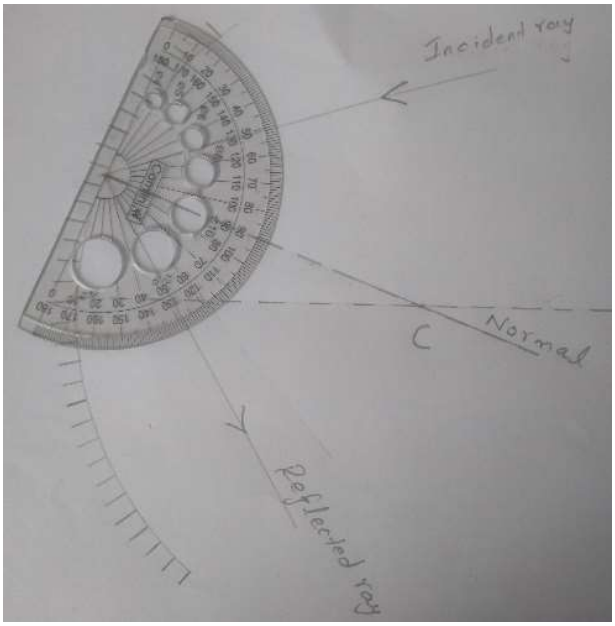


Fig. 6. Verifying the Laws of Reflection for a Light Ray Incident at Any Point on the Mirror

"You Do"

15. Ask the students to choose any point on the mirror as the point of incidence and verify the laws of reflection from that point.
16. Move around the groups and clarify the doubts faced by the students and ensure that all the students have a clear understanding about how laws of reflection are verified for curved mirrors.

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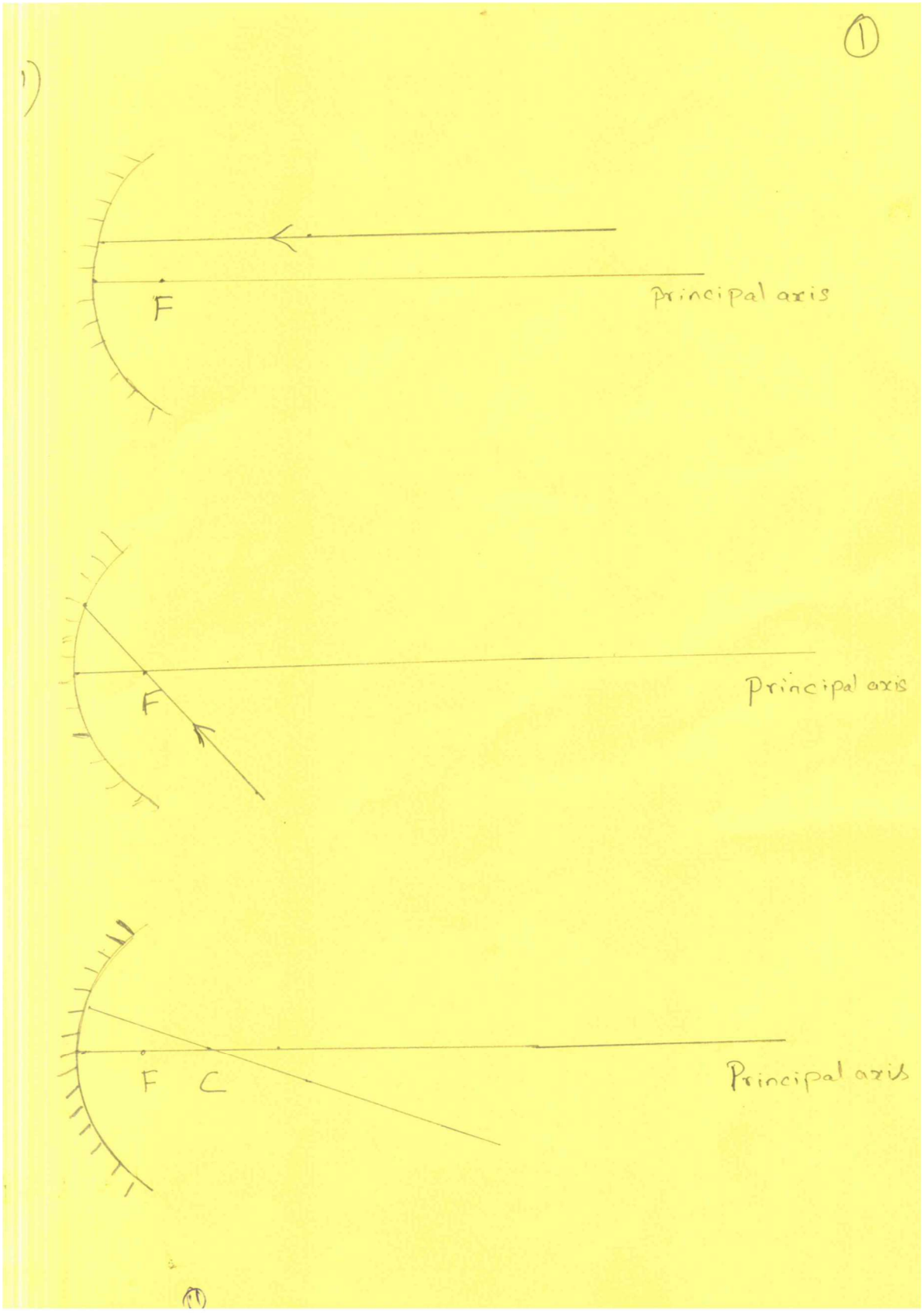
Annexure 1: Student Worksheet



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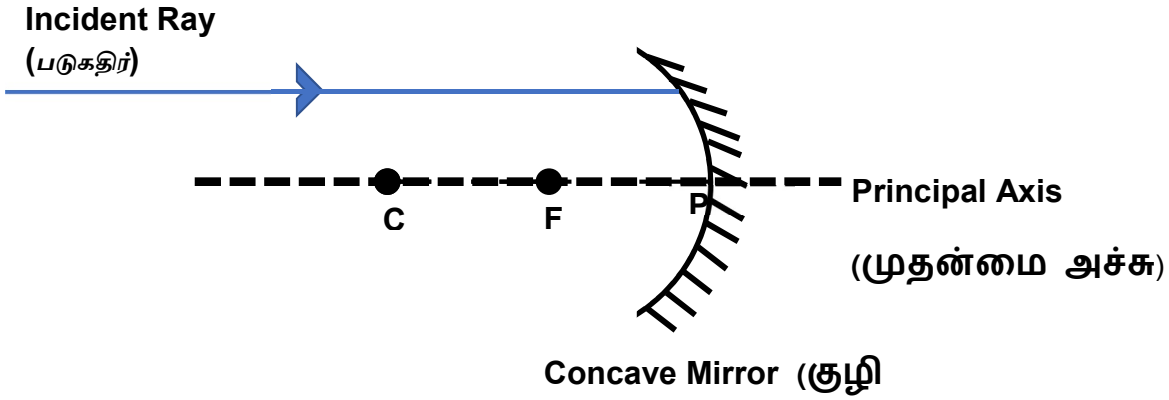
Annexure 2: Student Assessment

Draw the reflected rays for each of the following cases:

பின்வரும் நிகழ்வுகளில் ஒளியின் எதிரொளிப்புக் கதிர்களை வரைக.

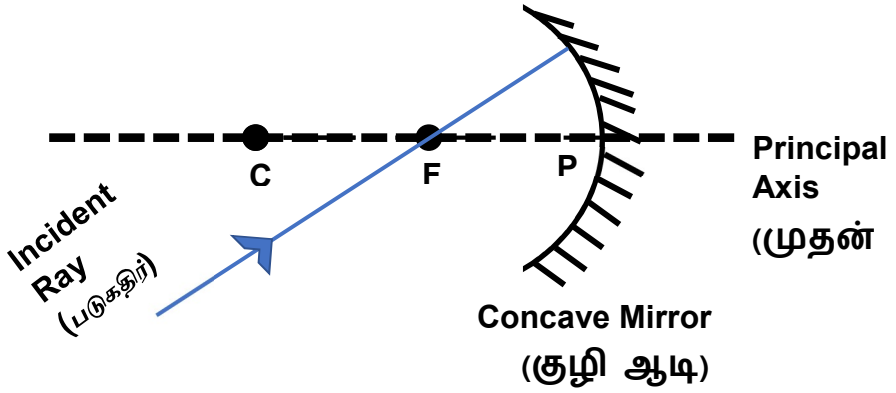
1) Incident ray runs parallel to the principal axis.

படுகதிரானது, முதன்மை அச்சுக்கு இணையாக உள்ளது.



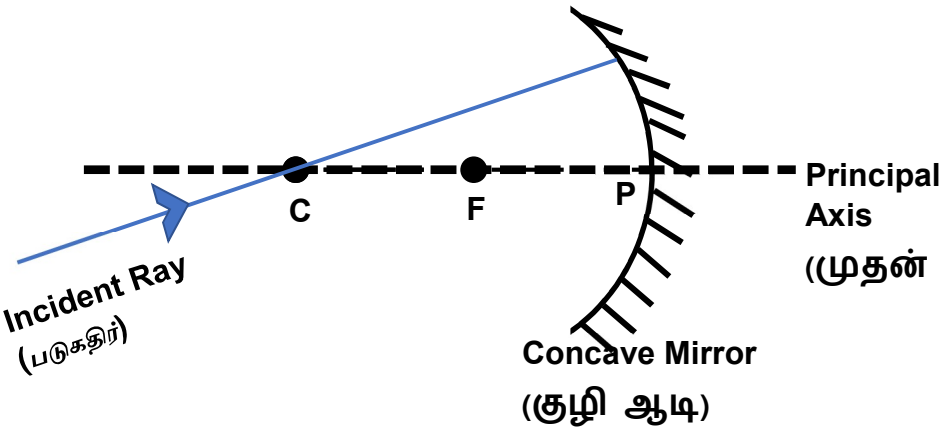
2) Incident ray passing through the focus (F).

படுகதிரானது குவியம் (F) வழியாகச் செல்கிறது.



2) Incident ray passing through the centre of curvature (C).

படு கதிரானது ஆடியின் வளைவு மையம் வழியாகச் செல்கிறது

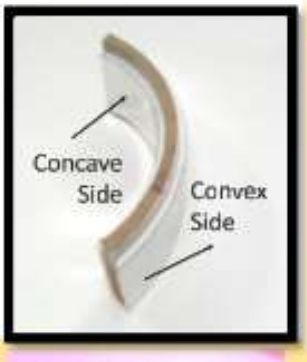


Annexure 3: How to Make a simple cylindrical concave mirror

Making a model of Curved Mirrors

Objective & Use

In order to demonstrate the rules of reflection in concave and convex mirrors a simple model of the same can be made using low-cost materials



Materials required

1. Core of a used up cello tape
2. Double sided tape
3. Aluminium Reflector sheet (Available in automobile shops)
4. Steel Scale
5. Cutter
6. Scissor

Procedure

1. Take a thick cardboard core of used up cello tape and cut it into 3 pieces. Care needs to be taken so that the curvature of the core is not altered.

2. Stick double side tape onto the inner and outer surfaces of the curved piece. Take care to ensure that the pasting is done smoothly without bends.

3. Use Steel scale and cutter to make neat strips of Aluminium reflector.

4. Stick the Aluminium reflective strip onto the double side tape, to make concave as well as convex surfaces. Take care to ensure that the stuck sheet is smooth without wrinkles, else the reflection can get unpredictable.

Advantages of this model : Low cost, easy to make.

Disadvantages of this model : Rules of reflection in curved mirrors can be demonstrated only as an approximation

Note : Care needs to be taken to ensure that the base where the model of mirror rests on the table is even and flat.

Precaution : To be made under adult supervision