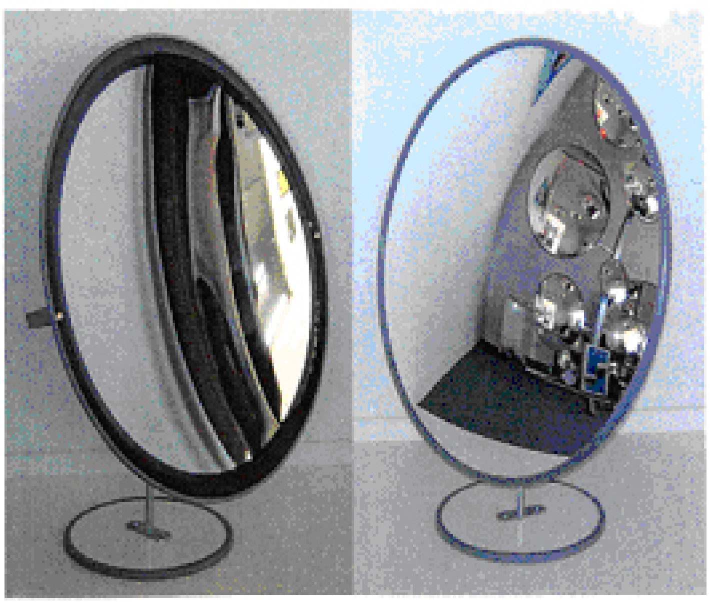
Arbor Scientific

Concave and Convex School Mirrors

Specifically Designed For
Science/Physics Experiments



Our acrylic concave/convex mirrors are made of the highest quality mirrored acrylic and will provide many years of service. Each mirror is supplied with an aluminum frame, mounting bracket and base.

Please Note: The following simple demonstrations are best suited for Acrylic mirrors because of the accuracy of the curvature.

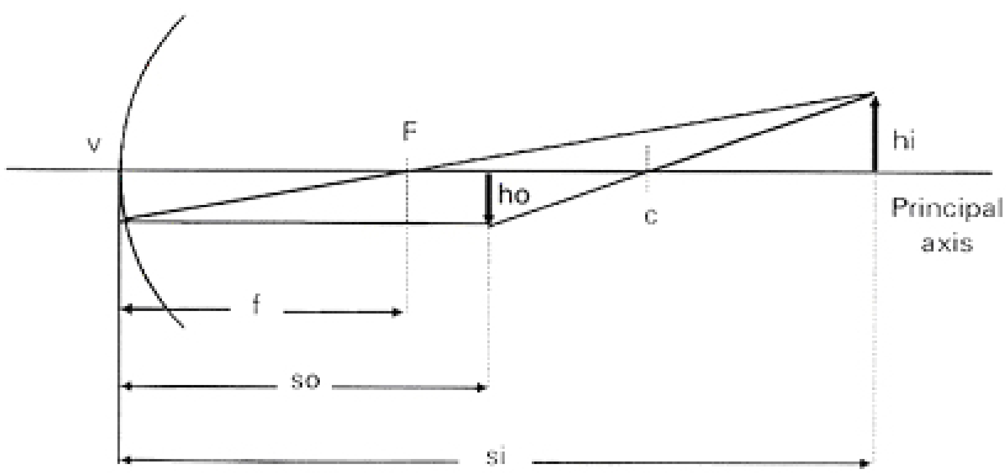
A brief description of these demonstrations are explained. If you have any interesting ideas, please contact us at the address shown on the front page.

Light

Basic Measurements
All basic quantities can be measured or calculated from the set up below. Mount the mirror on a tripod and place an object so as to protect an image onto a screen or wall. Use a solid rectangular shape for best results.

Magnification	$m = hi/ho = si/so$
Focal Length	$1/f = 1/so + 1/si = 2/r$
Power (Dioptres)	$D = 1/f$ metres

Sign Convention for concave mirrors:
so, r and f are positive, si is positive but becomes negative when $so < f$.



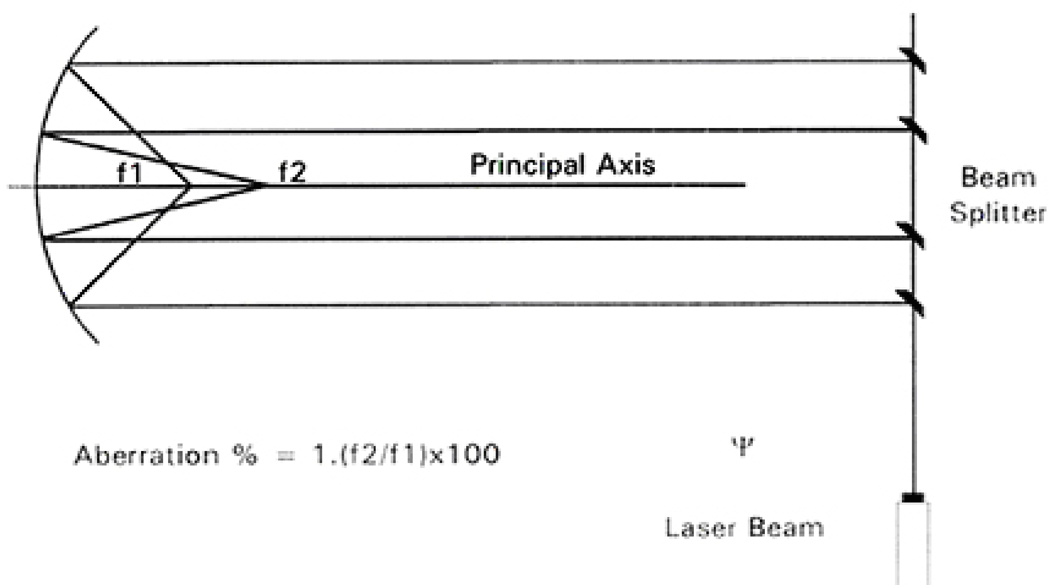
v = vertex r = radius of curvature c = centre of curvature
F = principle focus

Measuring Spherical Aberration

When a wide beam parallel to the principal axis is incident on a concave mirror, the rays further from the axis are focused at a point nearer the mirror than those close to the axis. This results in a blurred focus. By use of a laser and a beam splitter, the amount of aberration can be measured.

Set up a laser and splitter so that the beams fall on the outer edge of the mirror and record f1. Readjust beams for close to the centre and record f2. Use powder, steam or dry ice to illuminate the beams.

A beam splitter can be made by using a 2 way mirror available from an glass merchant. Purchase pieces about 2" square and mount at 45 degrees. Adjust to ensure the beams are parallel to refraction.



Aberration % = 1.(f2/f1)x100

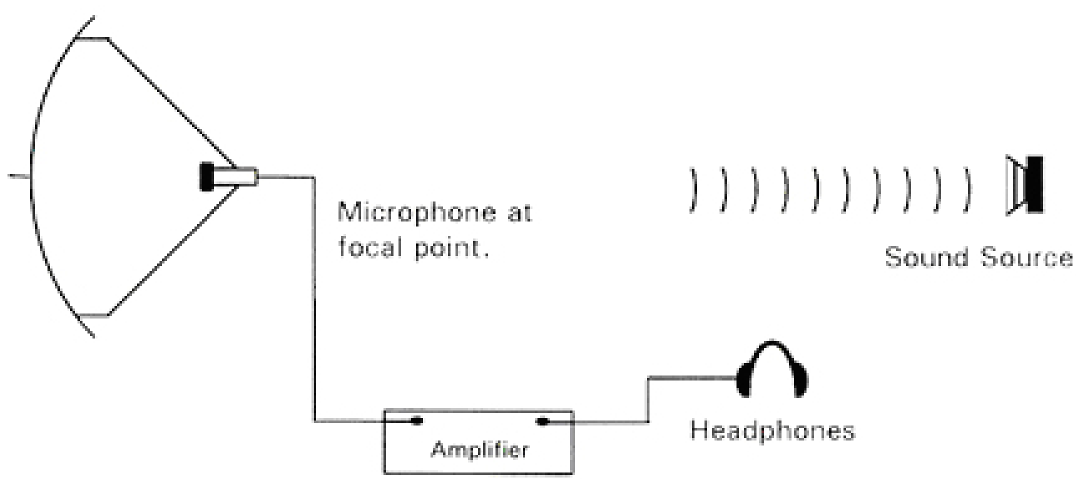
Sound

Mount a microphone using a focal mount and connect to an amplifier and headphones. Best results will be achieved in open areas with quiet surrounds. Point to a source (place a student at 13 to 16 feet counting to 30 etc). An increase in volume is noticed when the source is in line with the principal axis. Repeat at greater distances and discuss the affect beam width has on alignment. This simple demonstration proves that sound travels in parallel lines as does light. Student can calculate several quantities.

Audio Gain of Dish

Use an audio signal generator connected to an amplifier and speaker. Prior to placing the microphone at the focal point, measure the sound level of the source placed at 10 feet from the microphone using an oscilloscope or other measuring device. Record this measurement V1. Attach a microphone to the focal point and ensure the distance from the mirror centre to the source is 10 feet. Align for maximum level and record this measurement V2. Note on the oscilloscope that wave distortion takes place under certain alignment conditions, indicating phase canceling. Discuss reasons for this affect.

Gain of dish = 20 LOG V2/V1



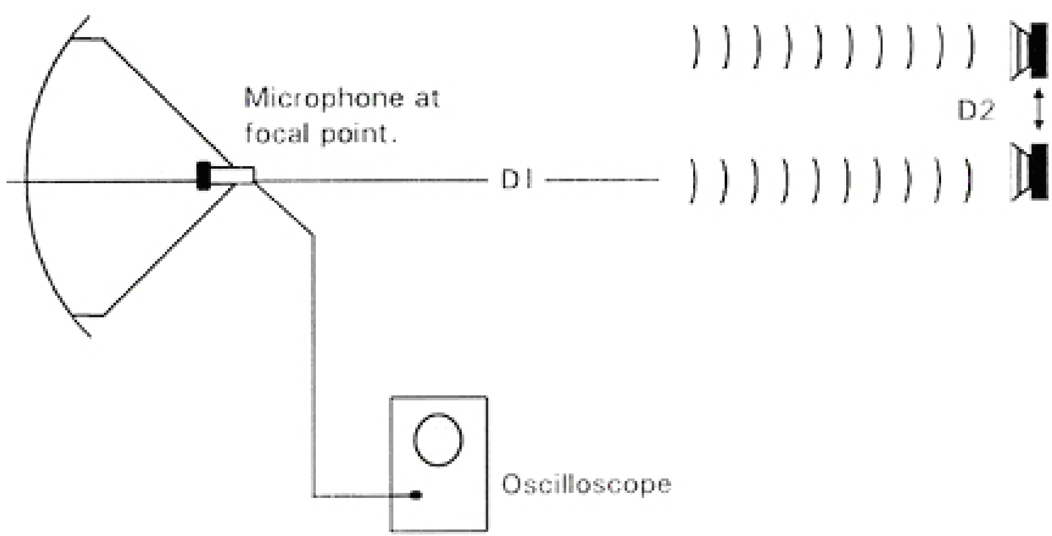
Beamwidth of Dish

Beamwidth is defined as the angle at which the voltage is reduced to half the maximum. In the above V2 is the maximum. By adjusting the alignment of the mirror for ½ V2, the beamwidth can be found by measuring the angular difference. However, a more accurate way is to shift the source sideways until ½ V2 is found. Record this shift D2. How much movement in the dish can be tolerated if listening to a sound from 65 feet away.

Beamwidth = TAN D2/D1

By accurately placing two mirrors in line with each other at a distance, a simple transmitter/receiver is created. Place a microphone at the focal point of one mirror and a small speaker at the other and align for maximum response. Sound from the speaker need be no louder than that required to overcome the distance between the mirrors (path loss). This demonstration illustrates the principal of microwave transmission. Substitute students at the focal points. The student speaking should have his mouth at the focal point while the listener will have to position his ears close to the focal point.

Either the concave or convex mirror will suffice for these demonstrations as the reflective qualities of the mirrors is of no consequence.

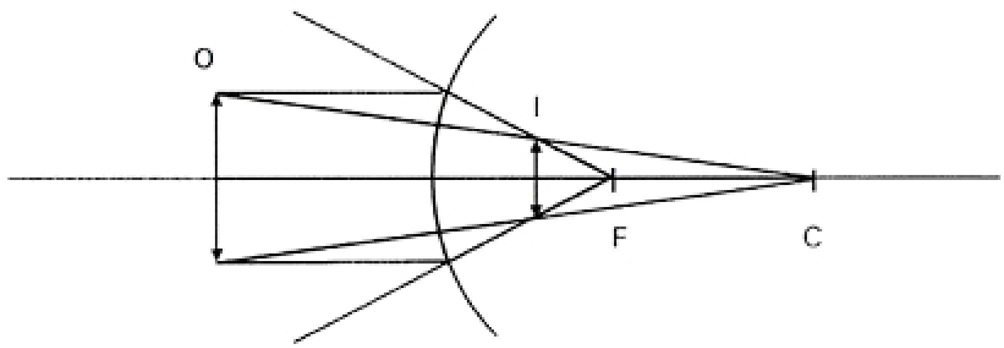


Convex Mirrors

The only image formed is virtual, erect, reduced and located behind the mirror.

Sign convention for convex mirrors:

so is positive; r, f and si are negative. The rules of signs only apply to parallel rays.



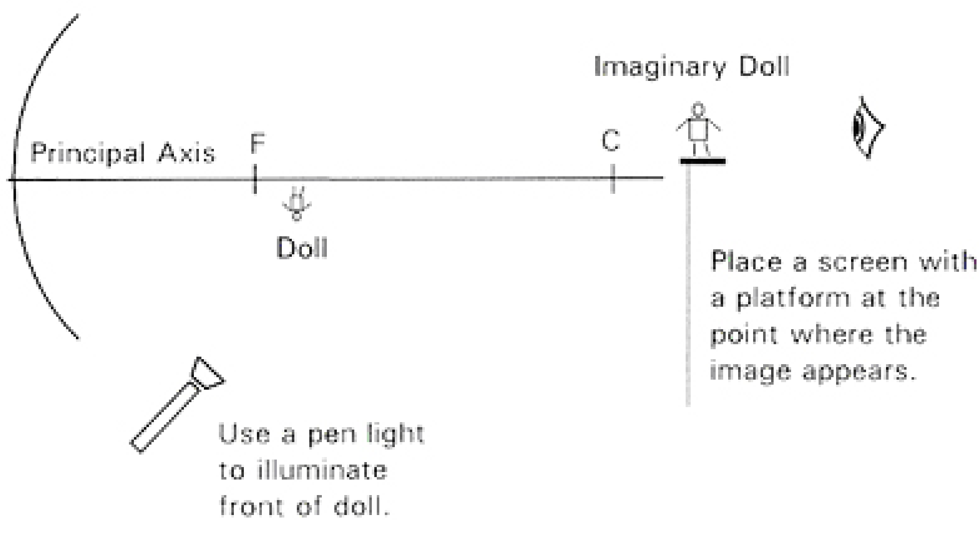
A convex mirror has a focal length of 14" with an object 3.3' in front of the mirror.
Where is the image formed?
How large is the image?

The Disappearing Doll

Support the concave mirror on a tripod or other mount at eye level and place an object upside down at a point close to the Focal Point (F). An image will be perceived to be in front of the mirror. The image can only be seen by viewing along the principal axis and it will appear as though the doll is standing on the platform. With subtle lighting and a screen the illusion is complete. Viewing away from the principal axis will reveal only a platform. An excellent demonstration and ideal for creating classroom discussion.

Is the image real or virtual?
Why is the image larger and inverted?
Draw a ray diagram to explain.

Predict changes to the image when the doll is moved towards F or C.
At what point along the axis is the doll the same size as the image?
What happens if the doll is placed between the mirror and F?



Solar Power and Heat

The concave mirror, when focusing sunlight, will generate extremely high temperatures at the focal point and proper supervision must be maintained whenever the mirror is used outside. NEVER focus the sun on any parts of the body or shine onto the face.

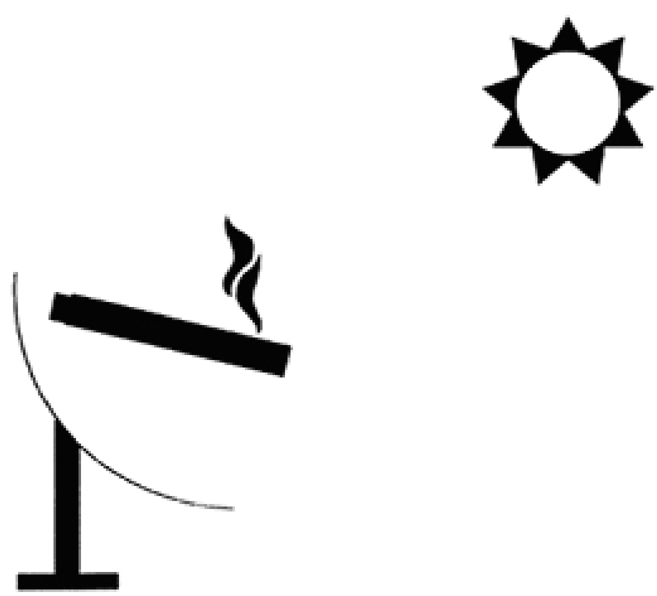
A dramatic demonstration of the amount of energy available from the sun is to simply focus the sun onto a piece of timber. Softwood is best for this and will burst into flame in about 1 second. Because of the brightness, use welding goggles or very dark glasses to assist in focusing.

By measuring the temperature T2 at the focal point and knowing the ambient temperature T1, the concentration or gain of the mirror can be found.

Gain of mirror db = 10 LOG T2/T1

Compare this figure with that of the audio gain and discuss reasons for the difference.

To heat without burning simply shift the object to be heated away from the focal point. Some uses are Solar Heater, Solar BBQ.



Maintenance and Cleaning

To maintain the high quality finish, simply clean with detergent and a soft cloth. Use no harsh cleaners. The surface of the mirror is not glass and in the case of mirror scratches, the surface can be polished using Brasso in small amounts, finishing with a silicon wax such as Pledge. Remove dust with a damp cloth. This stops static electricity and the attraction of fine particles.

In the case of the concave mirror, ensure the mirror cannot be accidentally left where sun light can fall on the mirror surface. If not on display, store in the plastic bag and carton provided.

Any Ideas?

If you have any interesting experiments for our concave and convex mirrors, we would be pleased to hear from you so that we can tell others.

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