Study Guide: Mirrors

Shadows

1. Do shadows exist? Explain your reasoning.

2. Can shadows travel faster than the speed of light? Explain your reasoning.

One of the earliest studies of light was of shadows. It was from observing shadows that people first determined that light travels in a straight line. One interesting aspect of shadows is that they don't exactly exist. They are not "things"; they are simply the lack of light. For example, shadows can appear to move faster than the speed of light, but this is only because nothing ("no thing") is actually moving. Only the situation of where light falls is changing.

Shadows on the moon are black, and have sharp edges. In fact, it can be dangerous to step into your own shadow on the moon because you could easily step into a deep hole. Shadows on earth are not totally black and usually have fuzzy edges. This is because light scatters in atmosphere. Most shadowy regions are made up of multiple overlapping shadows. The **umbra** is darkest part of a shadow, where all shadows overlap. Surrounding the umbra is the **penumbra**, which is where only some of the individual shadows overlap.

Plane Mirrors

1. One wall of a room is covered with a plane mirror, how much larger will the room appear to be? Explain your reasoning.

2. Is is possible for a plane mirror to reflect an object that is NOT directly in front of it? If so, how is this possible?

3. If we arrange two mirrors at 90° and place a small object in front of them, how many images of the object will we see? Explain your reasoning.

4. If we move the mirrors to be arranged at 60°, how many images of the object will we see? Explain your reasoning.

Retroreflectors

A retroreflector is an arrangement of three mirrors arranged at 90° and perpendicular to each other to create a corner. Any ray that enters this set of mirrors will be reflected back toward itself in a parallel path. Retroreflectors are used for bicycle reflectors to reflect a car's headlight beams back towards the car. This alerts the driver while not blinding others. The same technique is used in cloth reflectors and many other situations.

Curved Spherical Mirrors

Curved mirrors are either **convex** (curving out) or **concave** (curving in). **Spherical** mirrors are uniformly rounded in three dimensions. Light rays are reversible; the Law of Reflection works the same in either direction. Therefore, the same shape that can focus rays to a point can take rays from a point and send them out in parallel rays (flashlight).

Terms	**Description**
C	Center of curve
M	Center of mirror
Optic axis	A line passing through C and M
F	Focal point. Light rays parallel to the Optic Access are reflected back through a common point.
f	Focal length. Exactly half way between C and M (1/2 the radius).

Convex Mirrors

Convex mirrors produce smaller images but have a larger field of view. (Example: rearview mirrors) *"Images in the mirror may be closer than you think!"* The focal point (F) and the the center of the sphere (c) are at the back side of the mirror. The focal point (F) is still half way between C and M. Rays parallel to the optic axis are reflected *as if they came from the focal point behind the mirror.* Convex mirrors ALWAYS produce images that are **erect** (right side up) and smaller than the object.

Concave Mirrors

The images produced by concave mirrors are more complex than those of convex mirrors. Concave mirrors form two different images depending on how close the object is to the mirror. When objects are further away, the mirror produces an image that is **inverted** and reduced in size. This image is formed by light from the object converging to form an image in front of the mirror. This is known as a **real image**.

When an object is closer to the mirror than the **central point**, the image behaves like a plane mirror, but the image produced is magnified. In this case, there is no light at the point of the image because the image is formed behind the mirror. This is known as a **virtual image**.

The essential different between real and virtual images is whether the light actually comes from the image location or only appears to. If the rays **diverge** upon reflecting, they can never come together to form a real image. Real images can be seen on a piece of paper placed at the image location, but virtual images can not be seen in this way because there is no light reflected onto this location.

Locating Images in Space

There are an infinity of light rays reflecting off of objects and mirrors, but we only need three rays to model how curved mirrors work.

1. The easiest ray to draw travels along any radius of the sphere. It strikes the mirror normal and is reflected back to itself.
2. The second ray approaches the mirror parallel to the **optic axis**, and is reflected back through the **focal point**.
3. The third ray is a reverse of the second ray. In this case, light travels through the **focal point**, and is reflected back parallel to the **optic axis**.

Ray	Incident Ray	Reflective Ray
1	Along radius	Back on itself
2	Parallel to optic axis	Through focal point
3	Through focal point	Parallel to optic axis

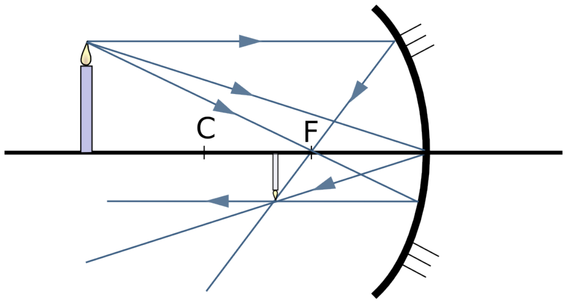

Figure 1: Object to M > 2f

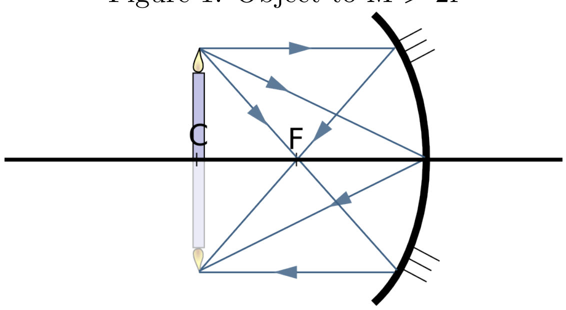

Figure 2: Object to M = 2f

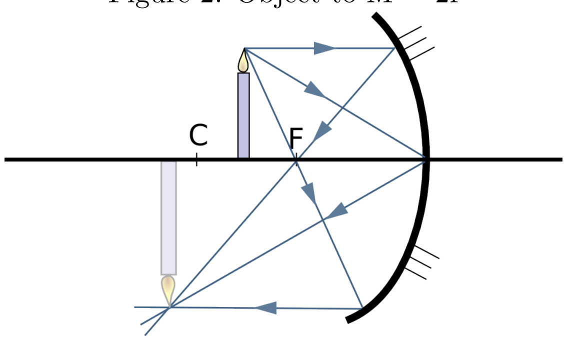

Figure 3: C > Object to M > f

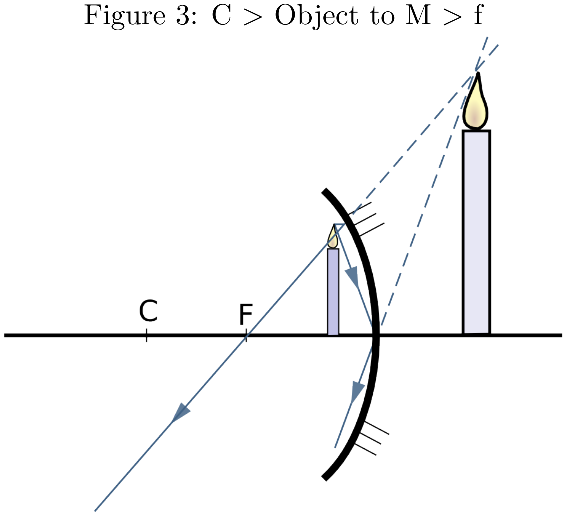

Figure 4: Object to M <> f