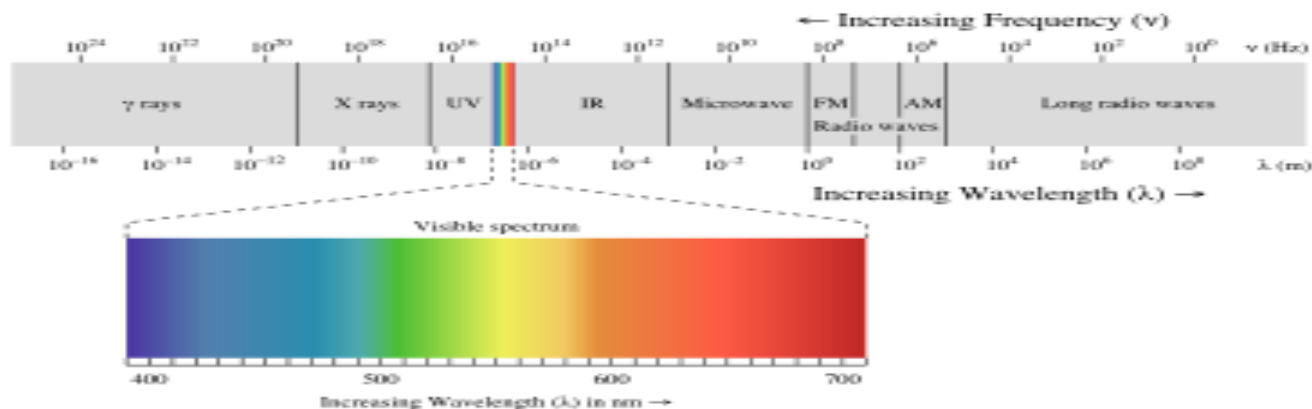
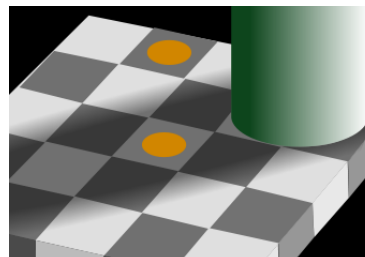
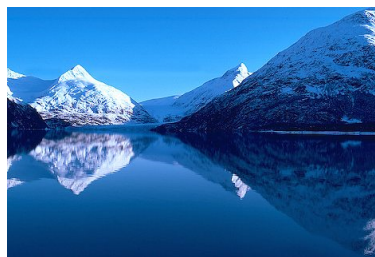
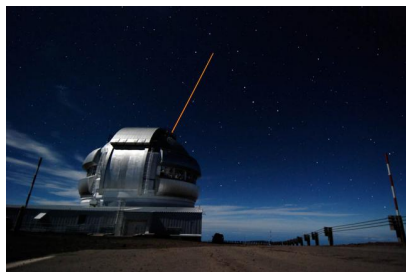


Physics 1230: Light and Color



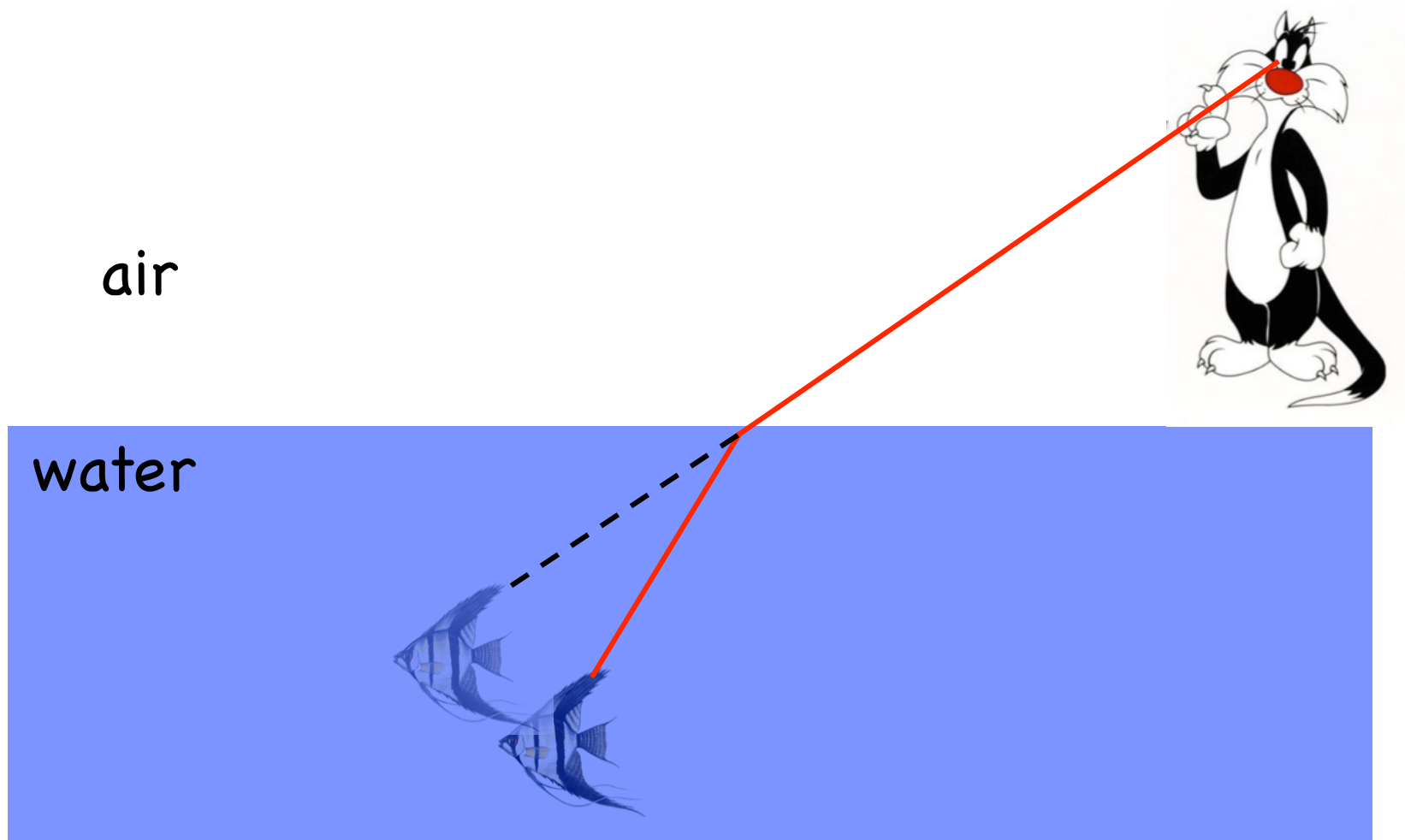
- Prof. Leo Radzihovsky
(lecturer)
- Gamow Tower F623
303-492-5436
- radzihov@colorado.edu
- office hours: T, Th 3-4pm

Susanna Todaro
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Duane Physics
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M, W 3-4pm

<http://www.colorado.edu/physics/phys1230/>

Refracted images

Key point: Image is formed along the extrapolation of the ray entering your eyes

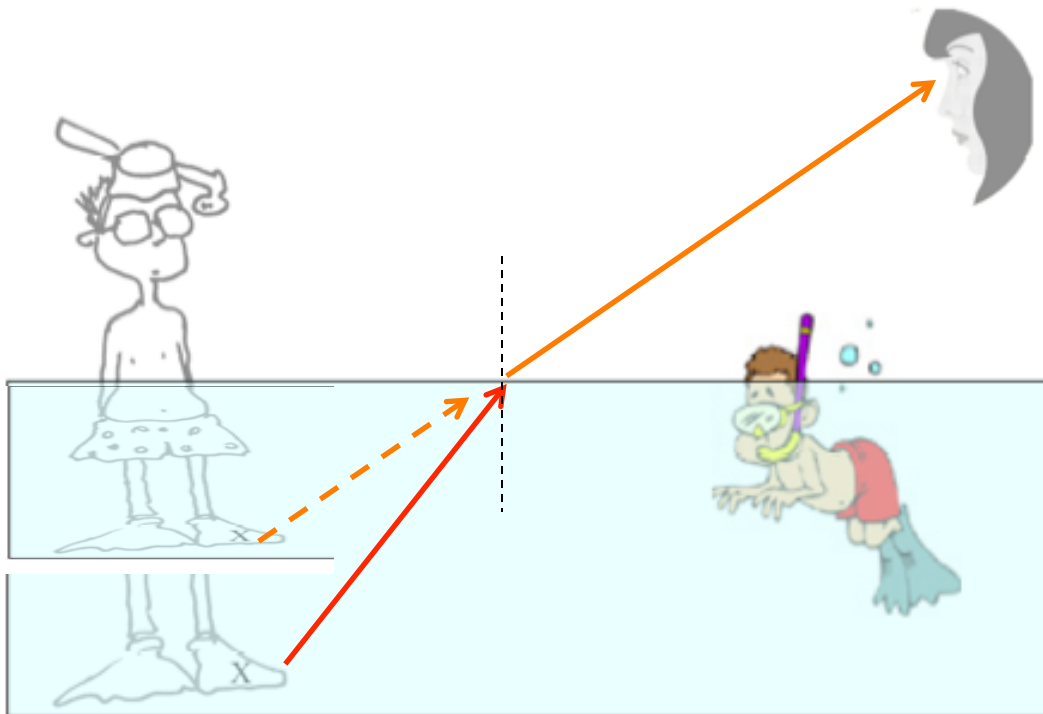


Refracted images

Q: Two observers, one above the water and one under the water, view an object (fellow to the left). The woman will see the underwater part of the body being

- a) shorter than it really is
- b) taller than it really is
- c) of natural size

A:

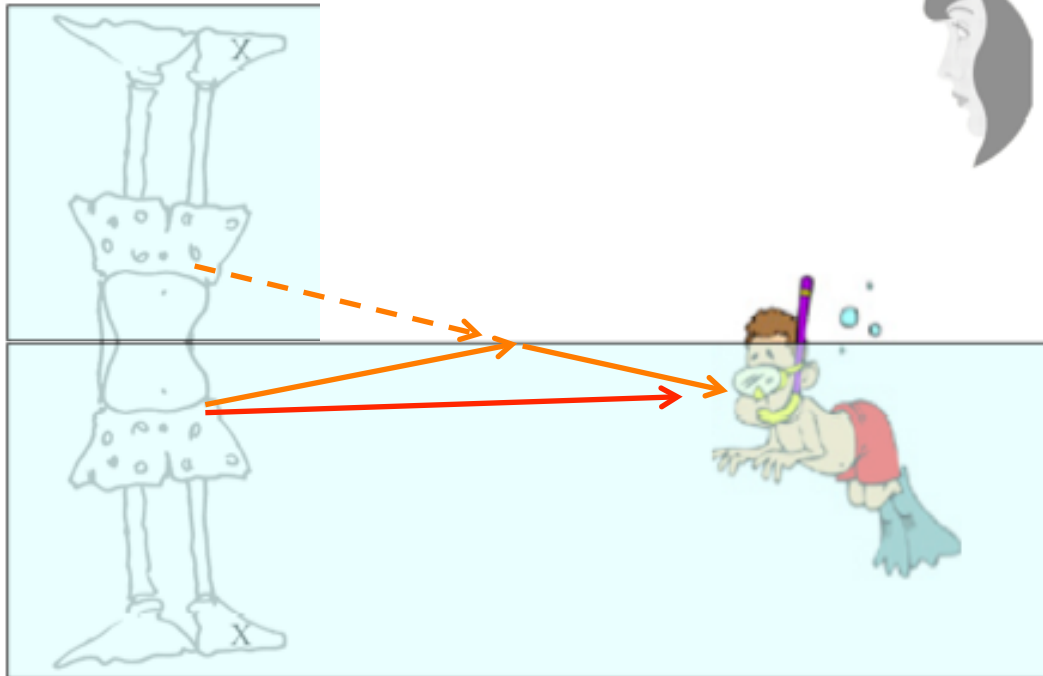


Refracted images

Q: Two observers, one above the water and one under the water, view an object (fellow to the left). The boy will see the underwater part of the body being

- a) smaller than it really is
- b) larger than it really is
- c) upside down image**

A:



Announcements:

- lectures 4, 5 are posted on the class website
- midterm 1, Thursday, Feb 20, in class
- homework 4 is posted on D2L
 - due Tuesday, Feb 18 in homework box in Help Room
 - solutions will be posted on D2L
- reading for this week is:
 - Ch. 3 in SL

recall lecture 4: Light propagation: ray optics

- from wave to ray picture



- shadows and apertures



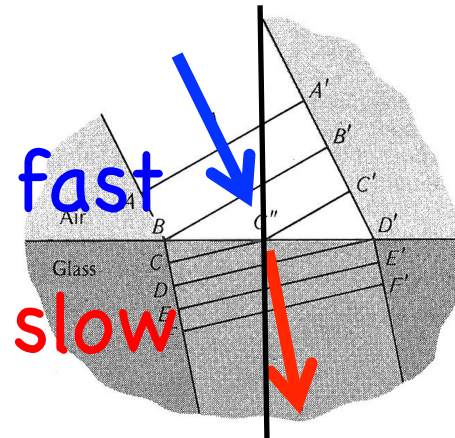
- scattering



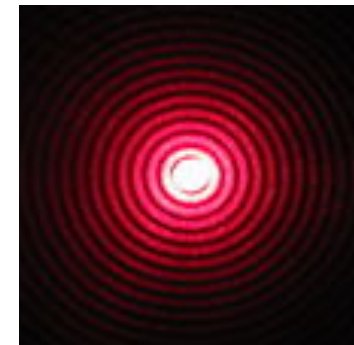
- reflection



- refraction

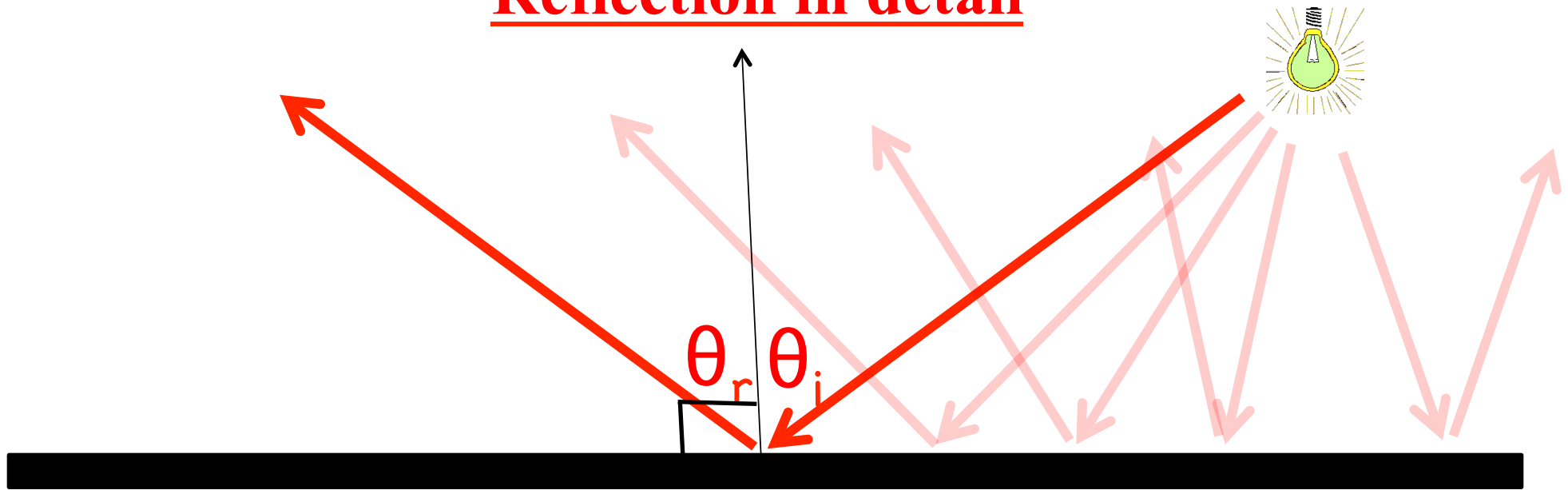


- diffraction



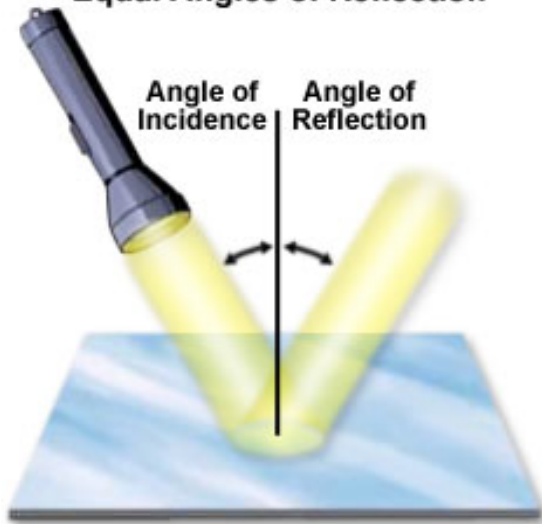
- absorption

Reflection in detail



smooth surface $\rightarrow$ specular reflection: $\theta_{\text{incident}} = \theta_{\text{reflection}}$

Equal Angles of Reflection



Smooth Water Surface



Wavy Water Surface

Diffusive vs specular reflection

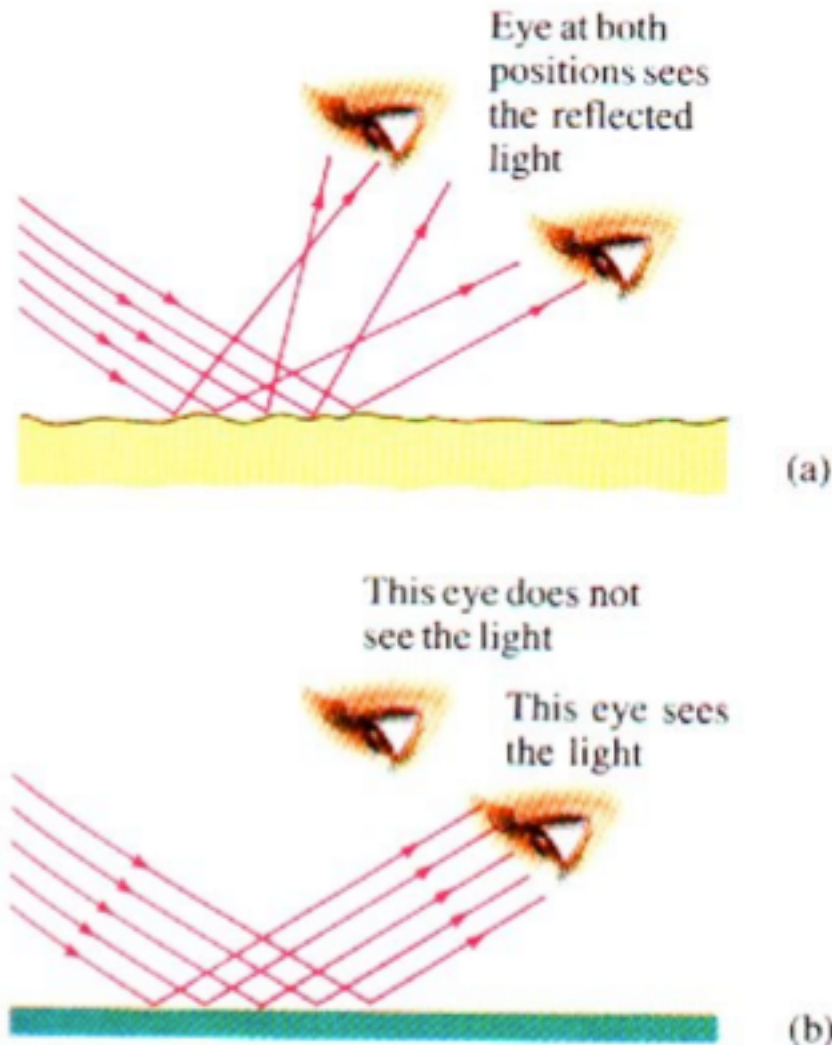


FIGURE 23–6 A beam of light from a flashlight is shined on (a) white paper, and (b) a small mirror. In part (a), you can see the white light reflected at various points because of diffuse reflection. But in part (b), you see the reflected light only when your eye is placed correctly ($\theta_r = \theta_i$); this is known as specular reflection.

Today

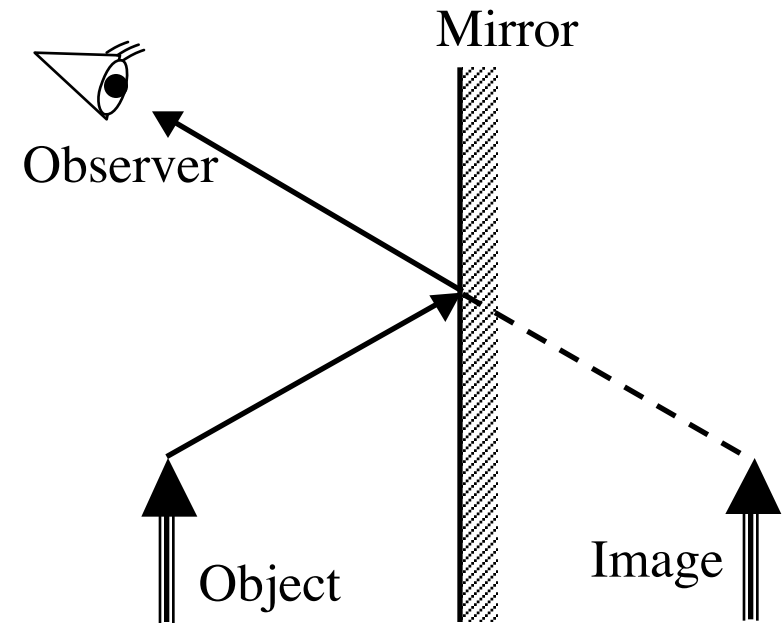
Image formation: mirrors & mirages

- real and virtual images
- image due to reflection: plane mirror
- image due to refraction: mirage, rainbow, sun columns
- optical illusions

Q: *Which is true?*

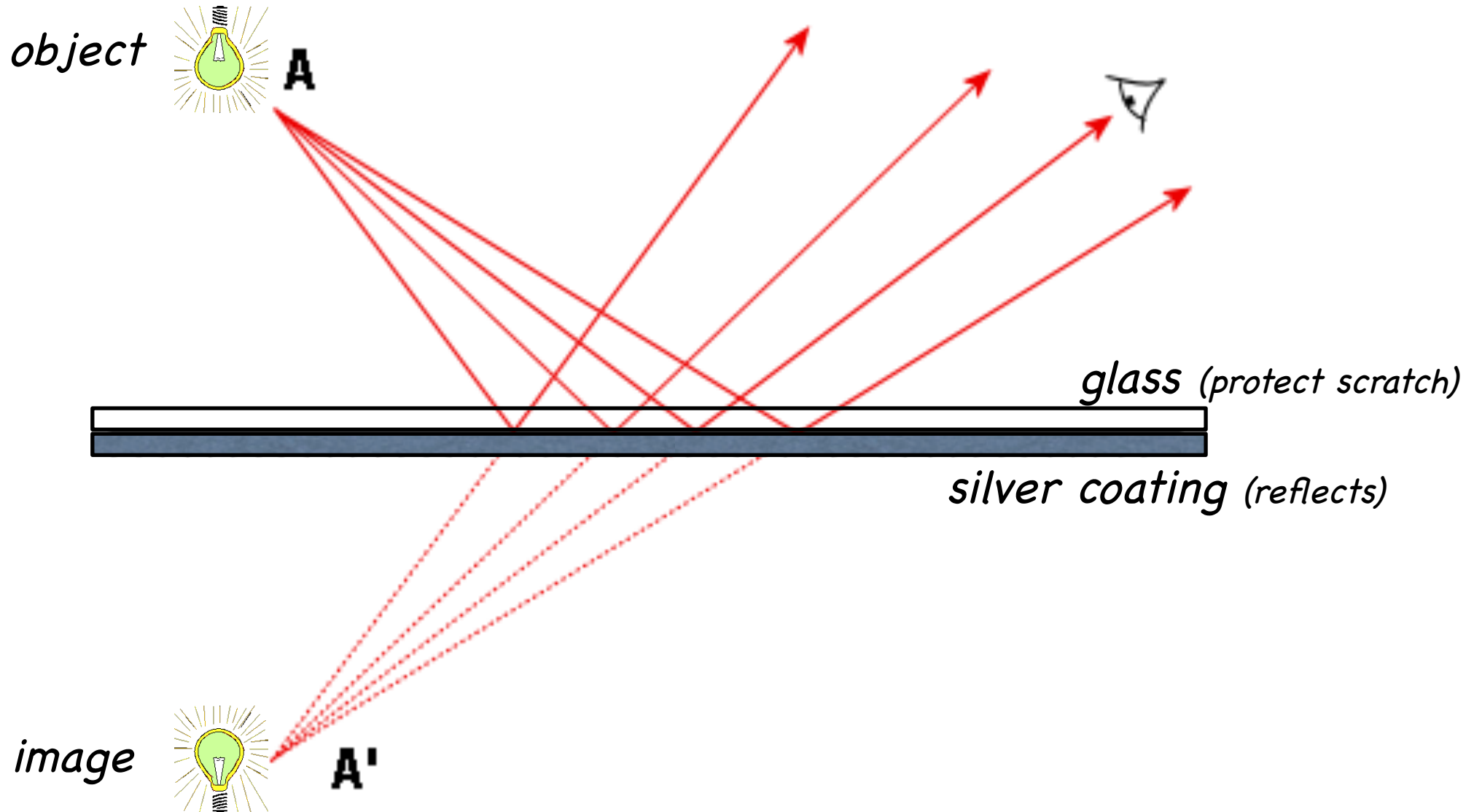
- a) There is only one ray of light from object to observer
- b) Only the tip of the object emits light. That light goes out in all directions. I drew one ray to keep it simple

c) All points on the object (effectively) emit light, in all directions. I drew one ray to keep it simple



A: *Even a non-luminous object "emits" rays of light in all directions because light well-illuminating it reflects diffusively in all directions.*

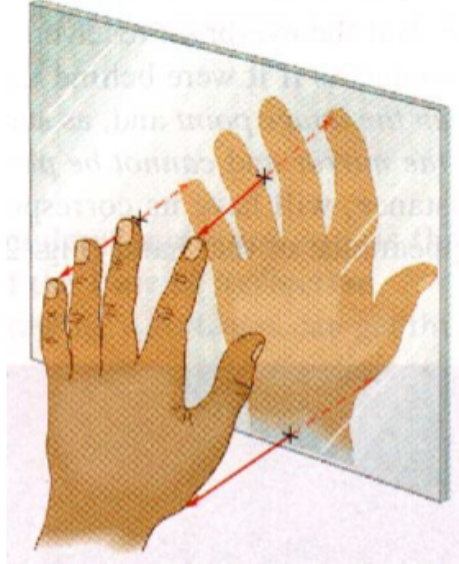
Specular reflection: mirror



Mirrors

can be

- plane:



- convex:



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Convex traffic safety mirror

- concave:

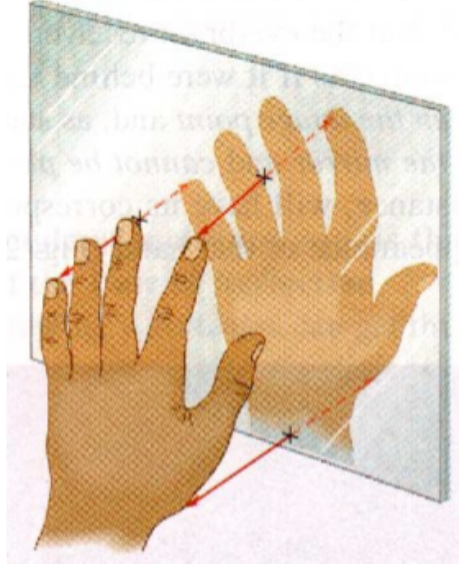


Concave solar concentrator

Mirrors

can be

- plane:



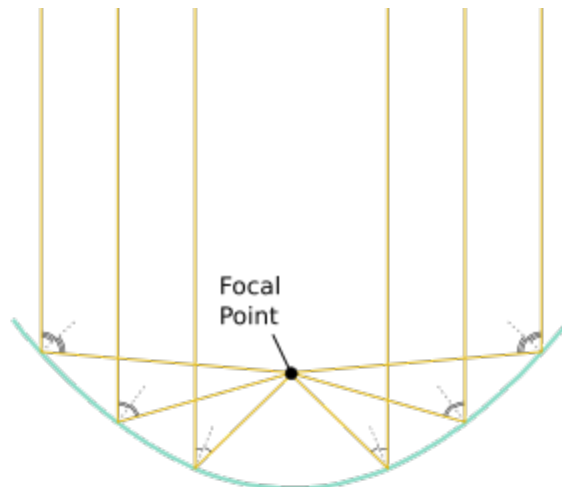
- convex:



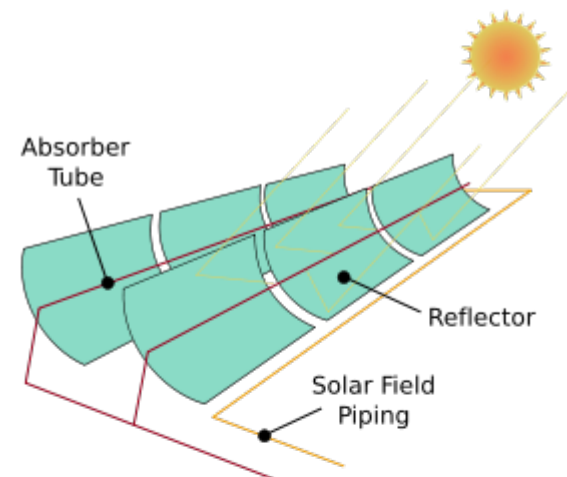
ALL rights reserved by JESSU BOND

Convex traffic safety mirror

- concave:

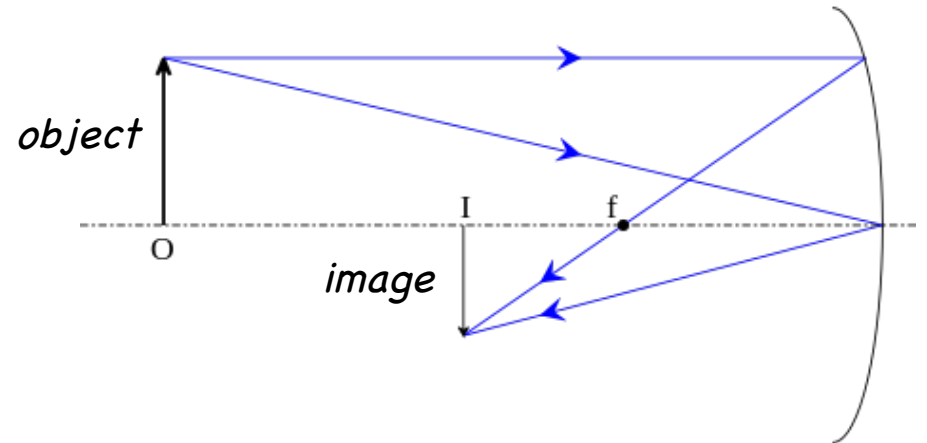
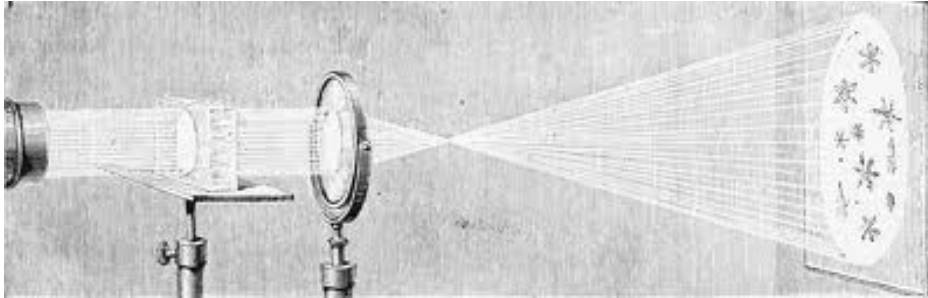


Concave solar concentrator

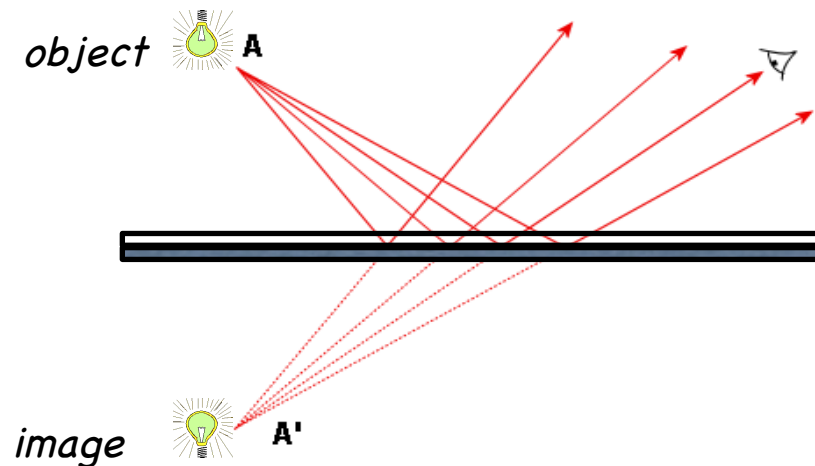
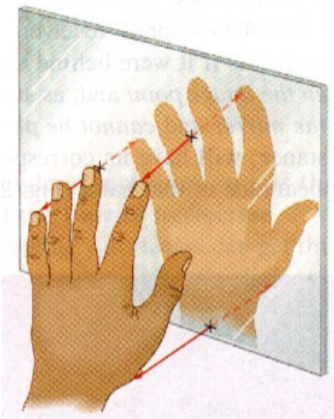


Images

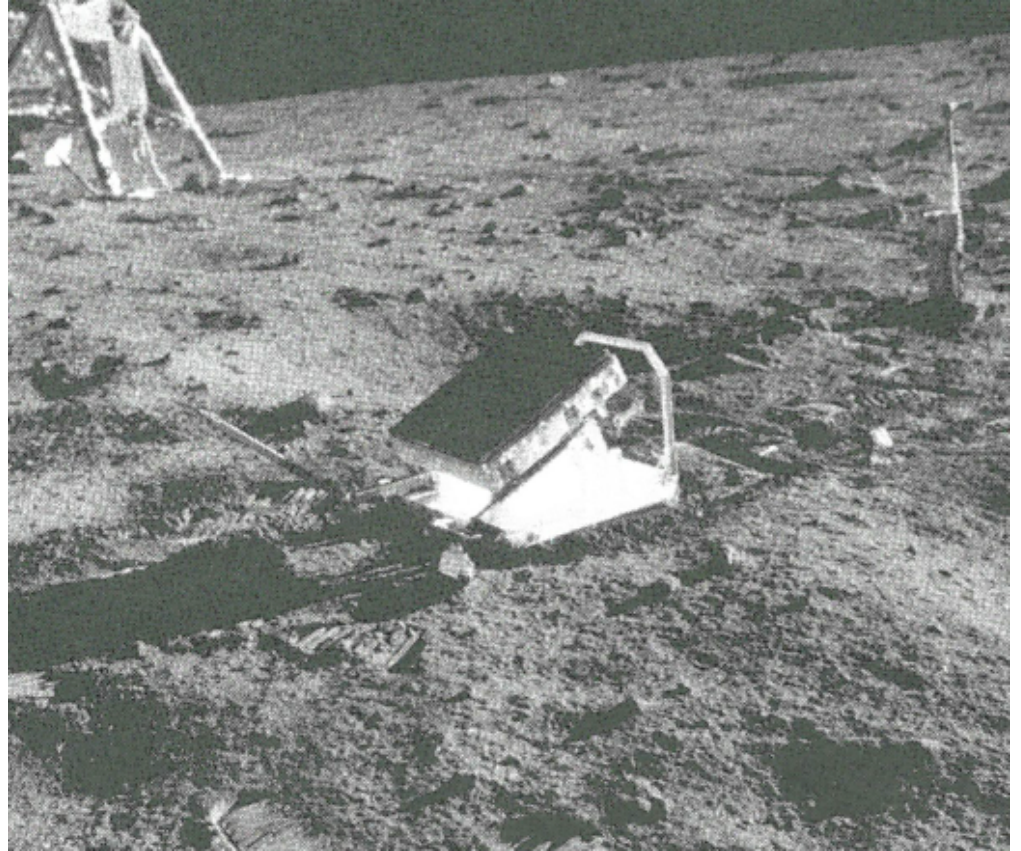
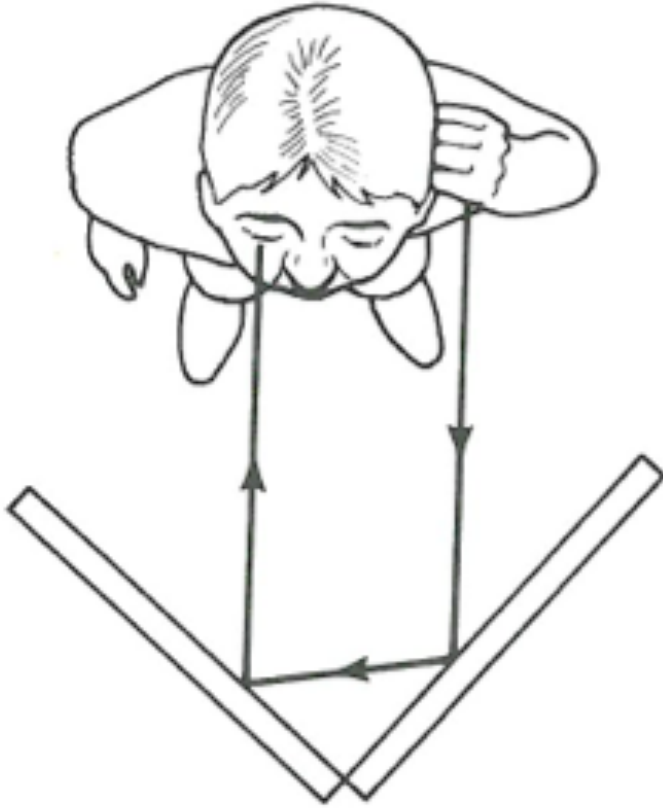
- **real image:** produced on a screen (or some other detector) when rays from a single point on an object strike a single point on the screen.



- **virtual image:** produced when rays of light reaching our eyes appear to come from a real object, but there is in fact no object at the apparent source of the light



Retroreflection mirror



- silver – 99% reflection
- glass – protects silver from scratching (only 4% reflection)

Image in a mirror

How is an image produced in a mirror? -> *ray tracing*

- incident ray from Alex's chin reflects from mirror and into Bob's eye
- Bob will see only this reflected ray from Alex's chin; others miss his eye
- another incident ray from Alex's hair reflects from mirror and into Bob's eye

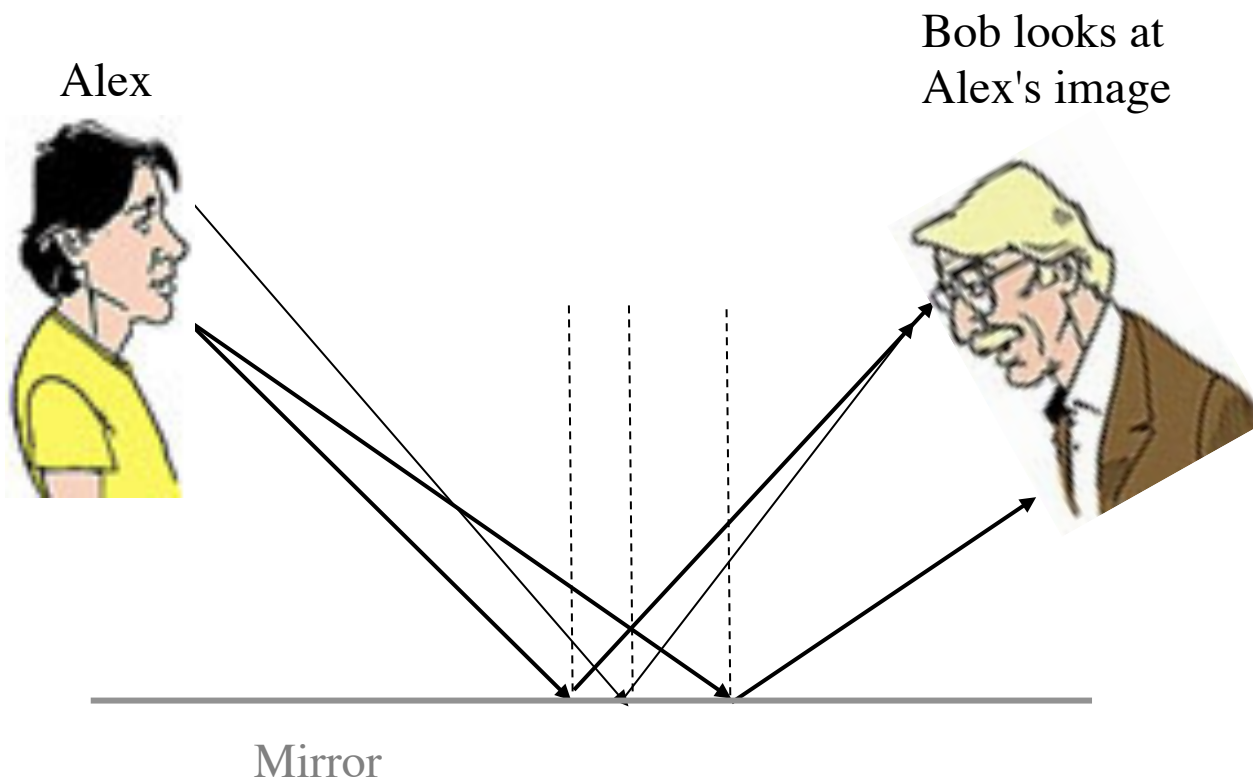


Image in a mirror

How is an image produced in a mirror? -> *psychology of ray interpretation*

- image of Alex is Bob's interpretation of reflected rays
- Bob cannot directly know whether the rays entering his eyes have been reflected or not
- we interpret all rays coming into our eyes as traveling from a fictitious image in a straight line to our eye even if they are reflected rays

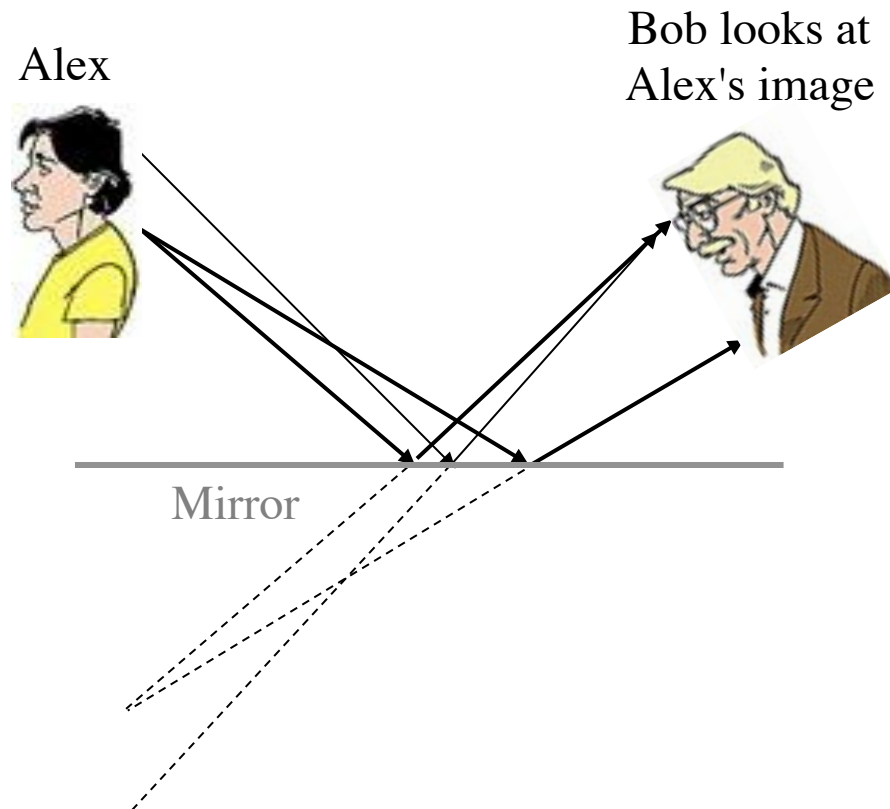


Image in a mirror

How is an image produced in a mirror? -> *virtual image*

- image of Alex is Bob's interpretation of reflected rays
- Bob cannot directly know whether the rays entering his eyes have been reflected or not
- we interpret all rays coming into our eyes as traveling from a fictitious image in a straight line to our eye even if they are reflected rays

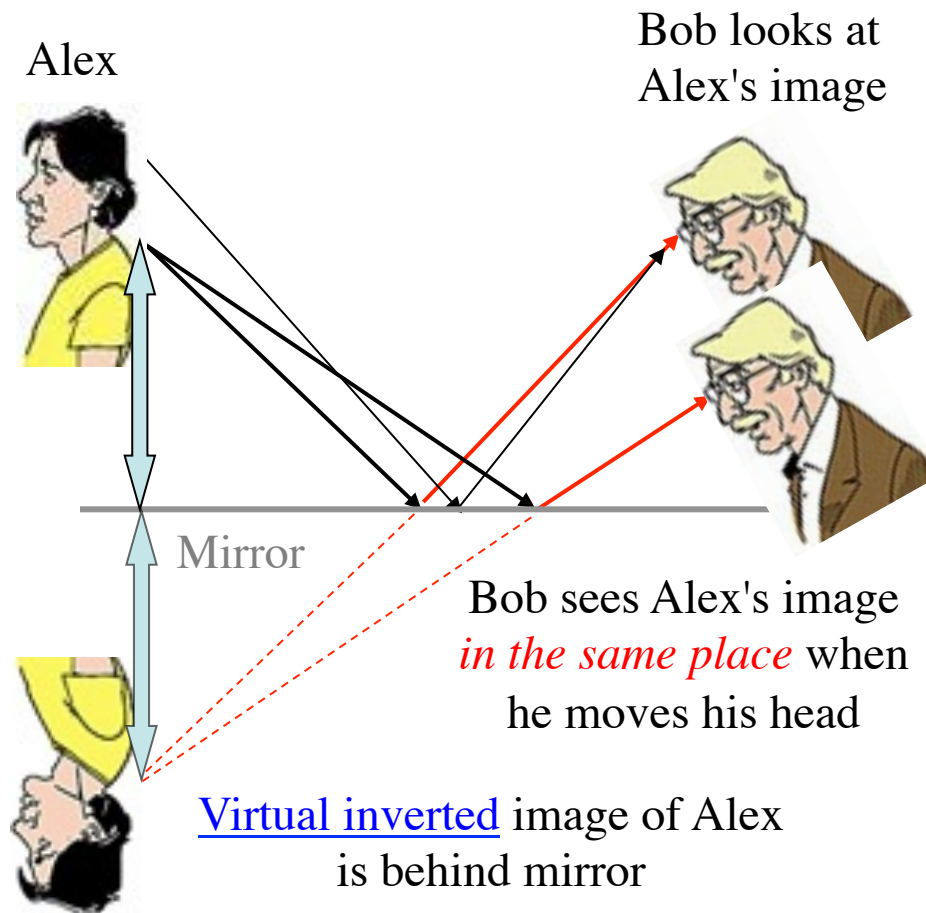


Image in a mirror

How we see an image

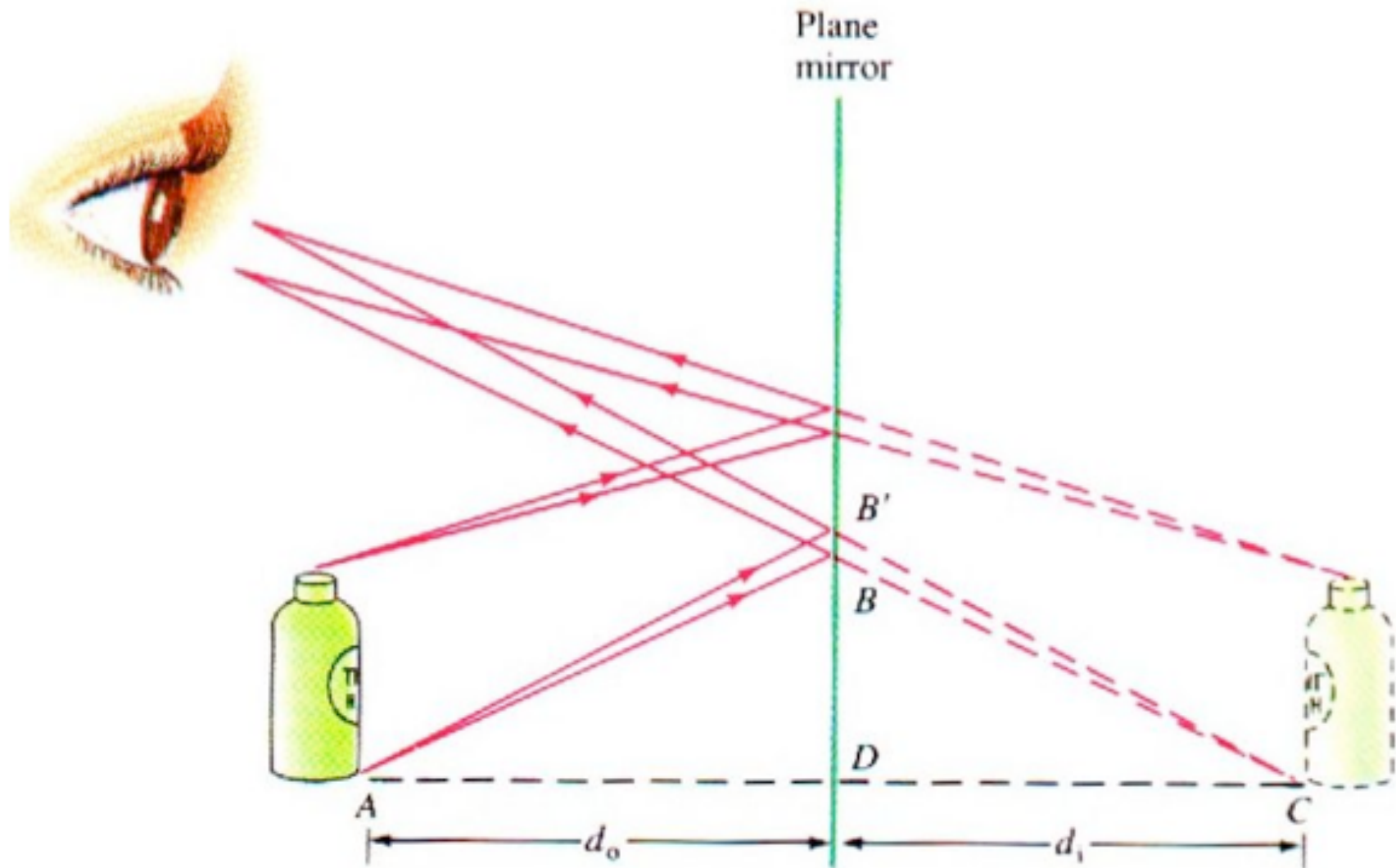
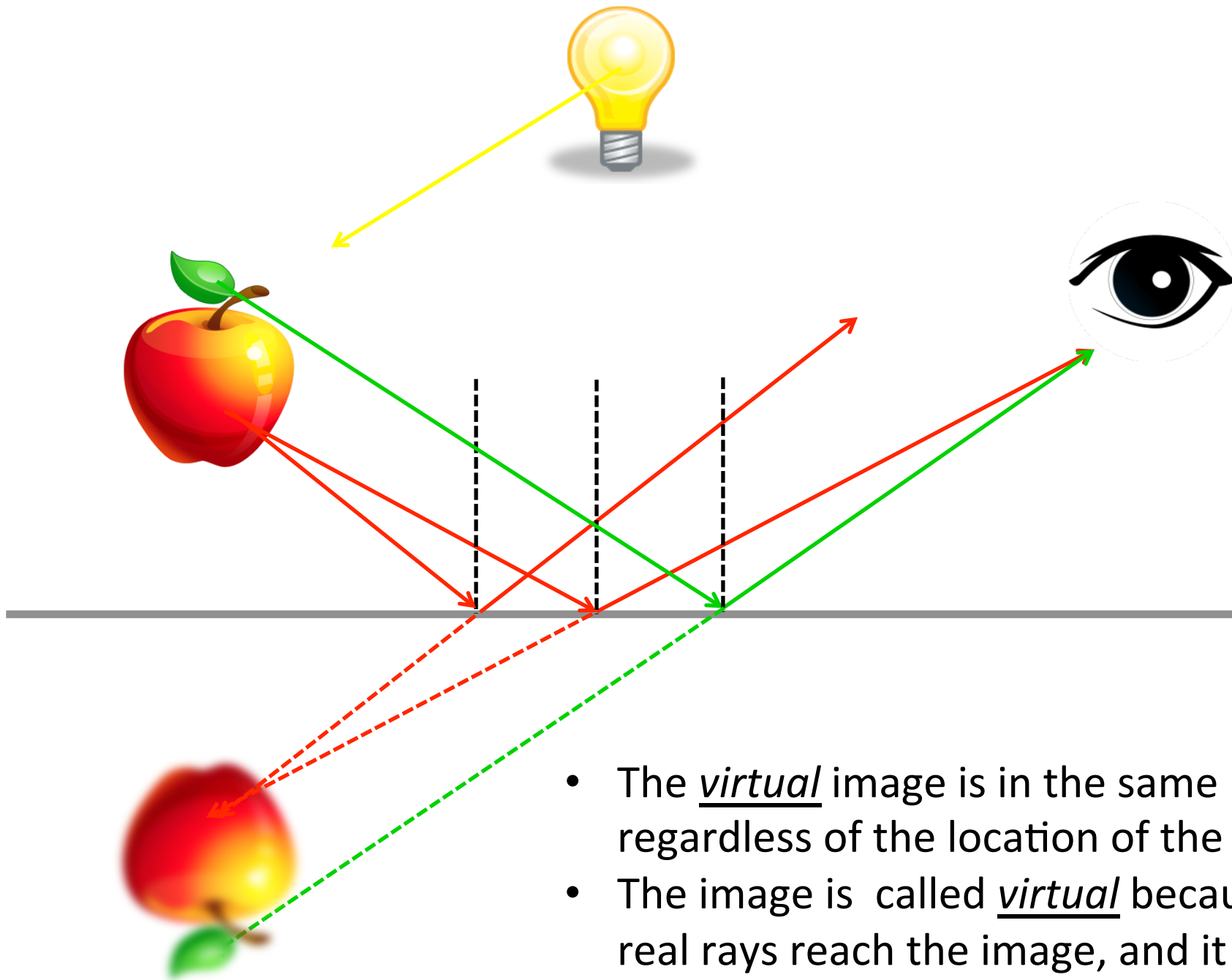


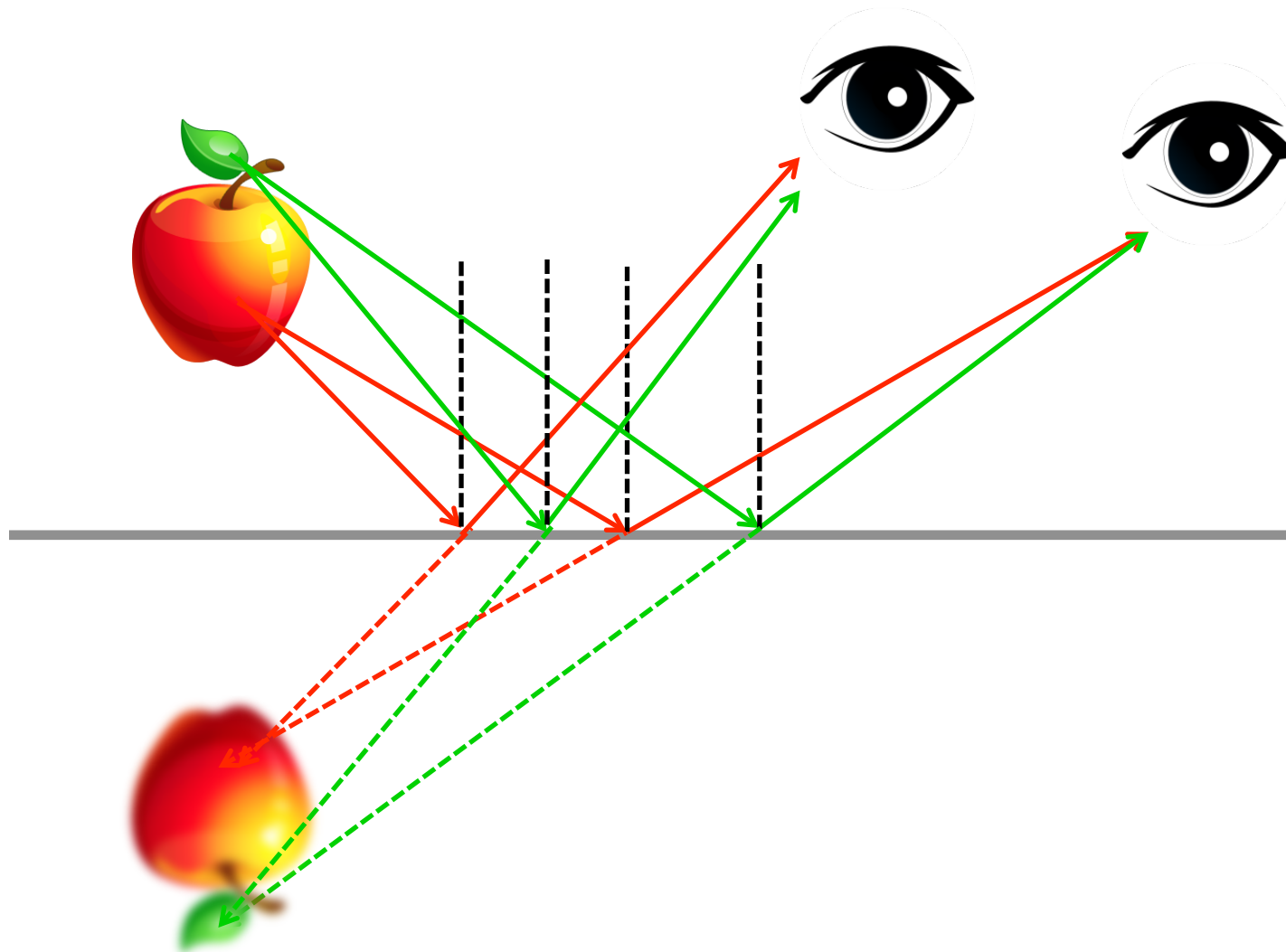
Image in a mirror



- The virtual image is in the same place regardless of the location of the viewer
- The image is called virtual because no real rays reach the image, and it cannot be seen by putting a screen at its position

virtual image

Image in a mirror



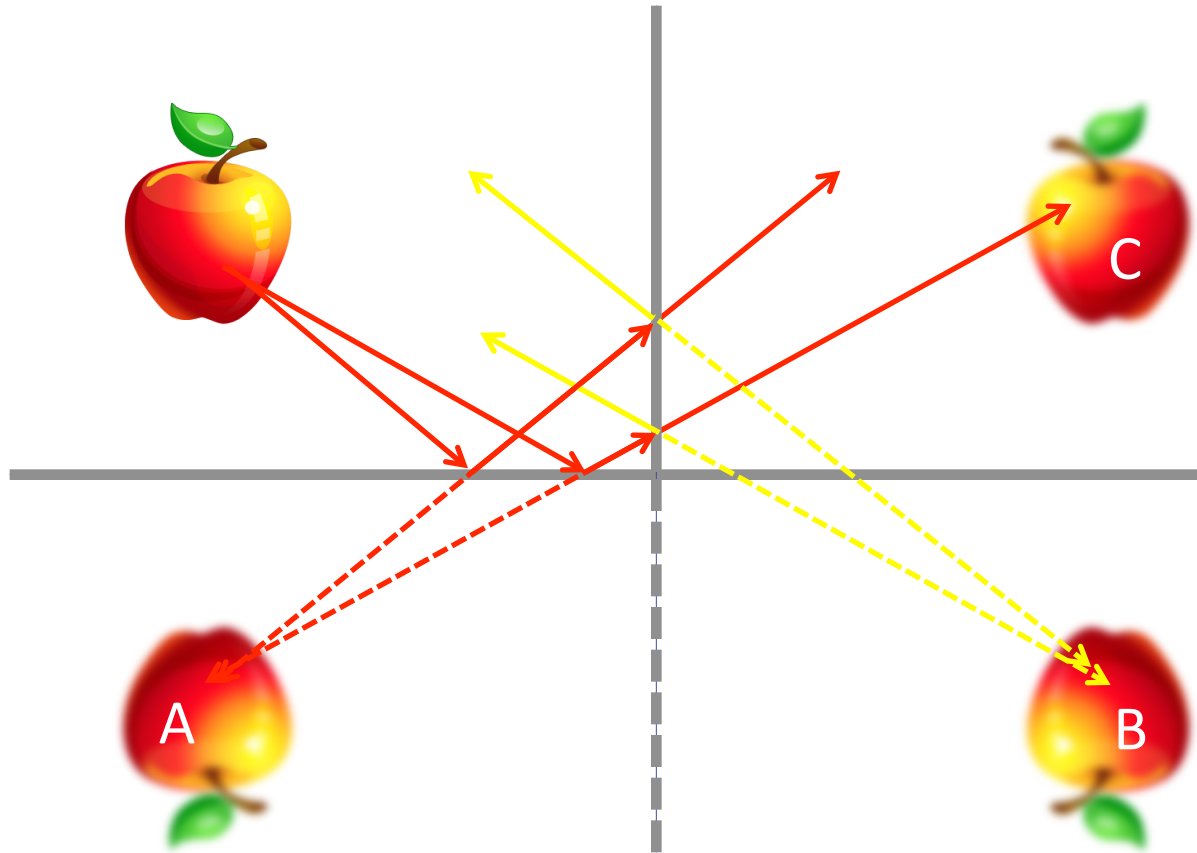
virtual image

- The virtual image is in the same place regardless of the location of the viewer
- The image is called virtual because no real rays reach the image, and it cannot be seen by putting a screen at its position

Image formation in a mirror

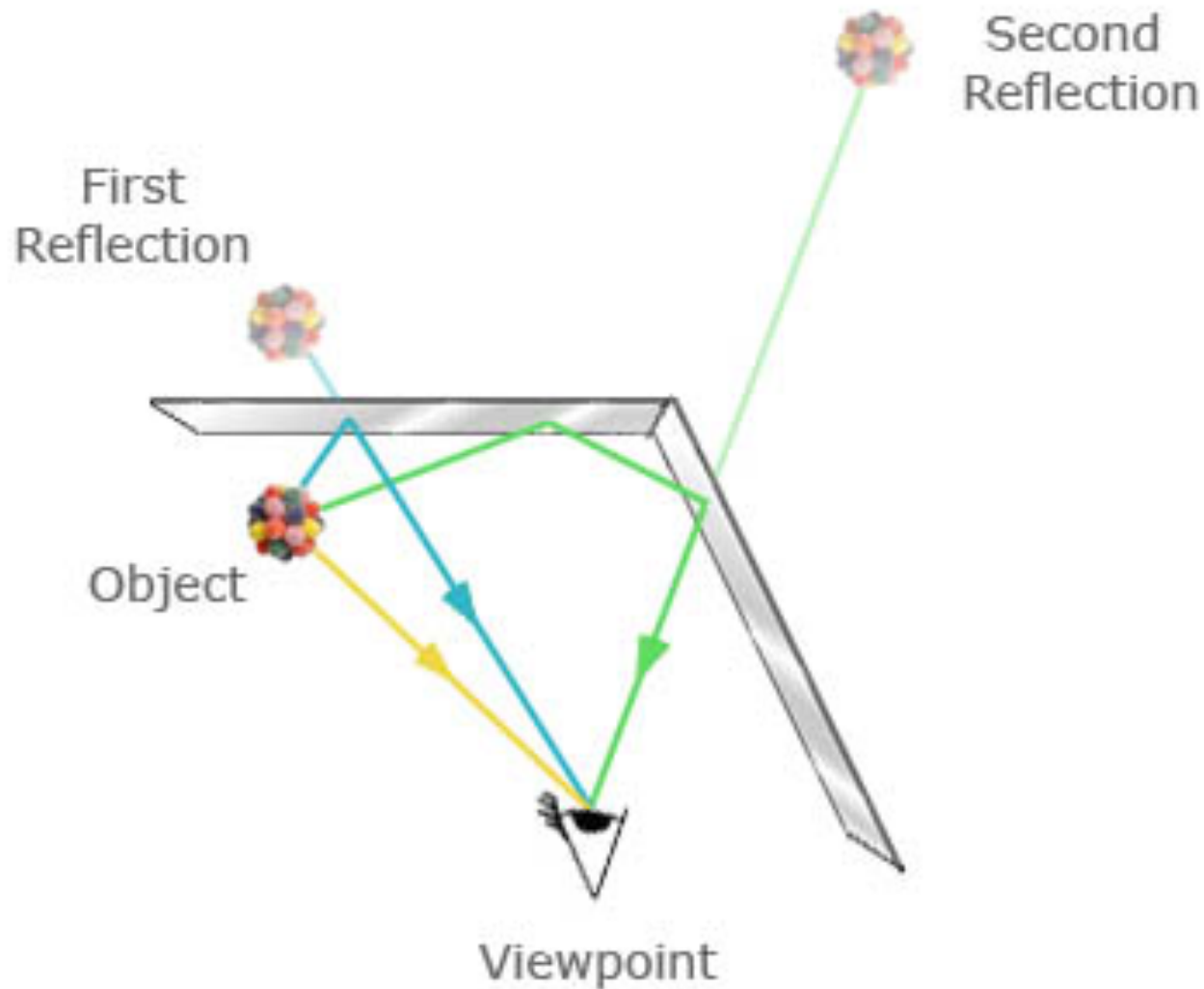


Image in multiple mirrors



A virtual image can act as an intermediate image and generate its own virtual image

Image in multiple mirrors



A virtual image can act as an intermediate image and generate its own virtual image