LIGHT AND SOUND

1. LIGHT

A.1. Think carefully about the next question: the space outside the Earth is continually traversed by the light of the Sun and other stars, why is it so dark?

A.2. Is light visible or invisible?

A.3. Write a two-column table with five objects that emit light and five objects that do not emit it.

A.4. Look for information about the following mechanisms of light emission from different objects:

a) Heating (Sun, light bulbs).

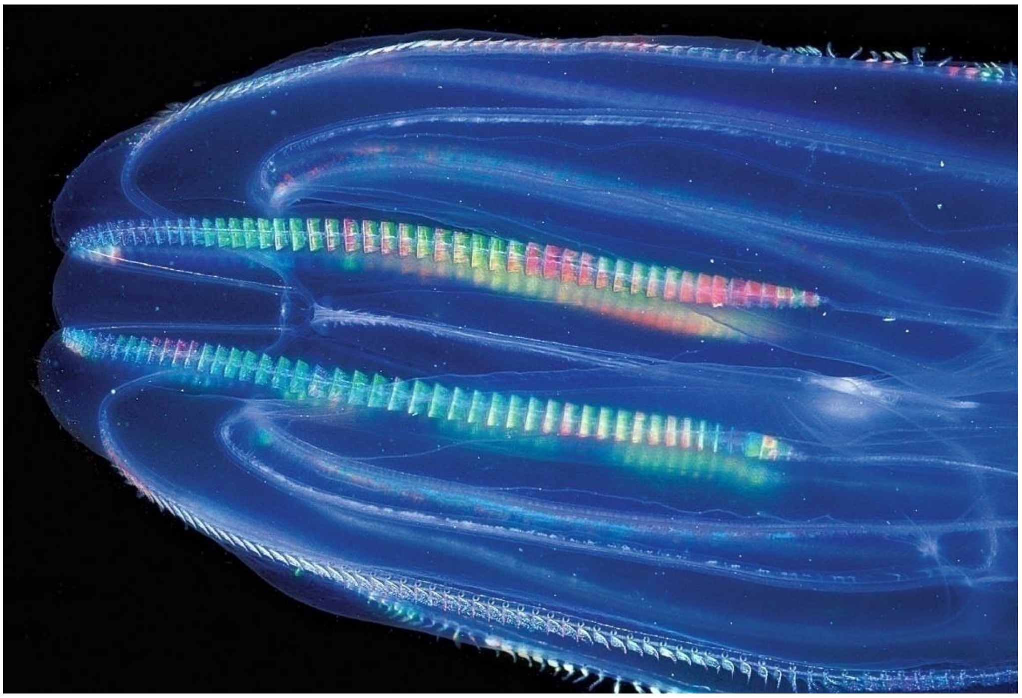
b) Electrical discharges in gases at low pressure (fluorescents, neon lights).

c) LEDs (little bulbs in Christmas trees).

d) Bioluminescence (fireflies).

e) Laser (CDs, DVDs).

The phenomenon of bioluminescence leads to strange and beautiful effects in Nature. If you are curious about it, you can visit the following video and the following link.



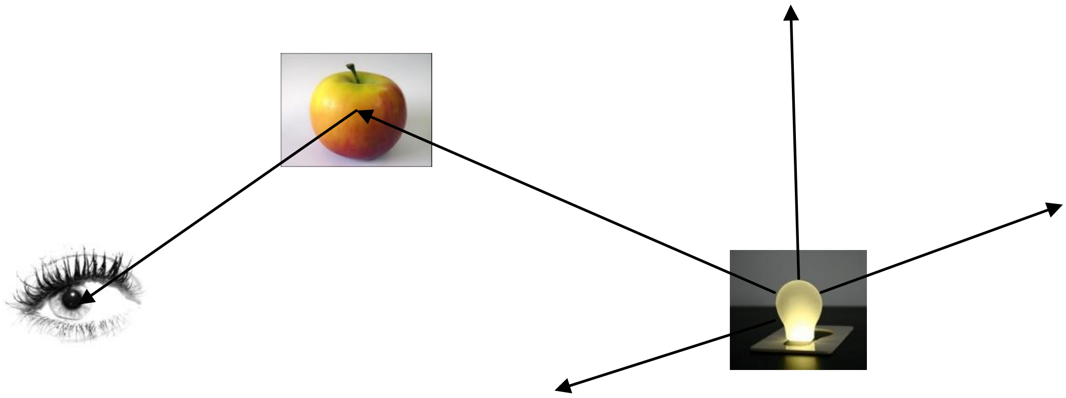
A.5. Some ancient thinkers believed that we can see because we emit light rays from the eyes. What do you think about this idea?

A.6. We turn on the light in the class. You can use a sheet of paper as a screen. Is there light:

a) in the fluorescent, the space between you and the fluorescent and on the sheet?

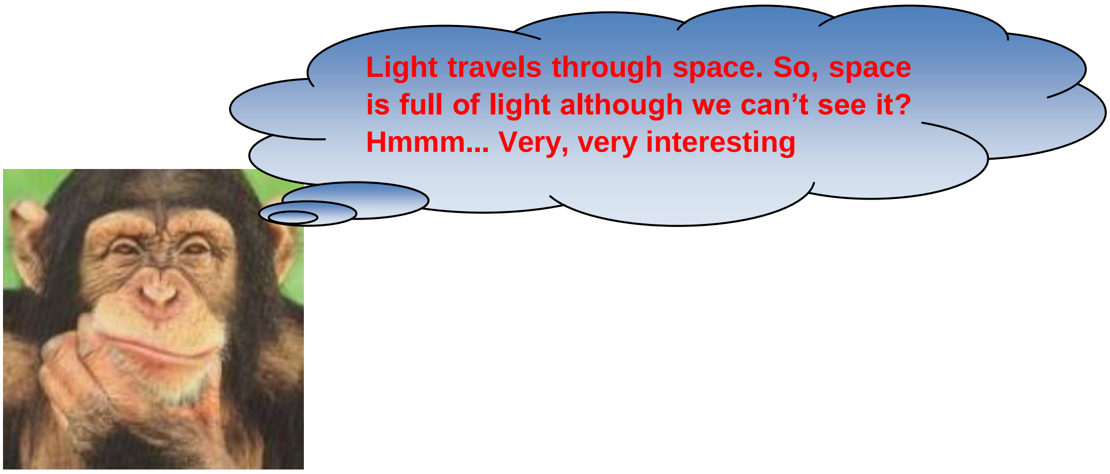
b) only in the fluorescent and on the sheet?

c) only in the fluorescent?

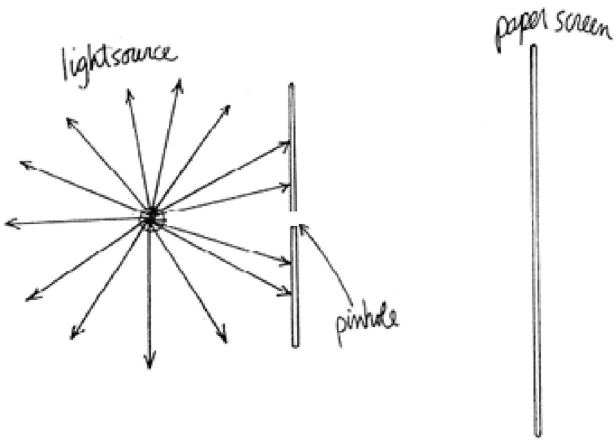


A.7. Based on the figure above, explain step by step what has to happen to see an object located between the bulb and your eye.

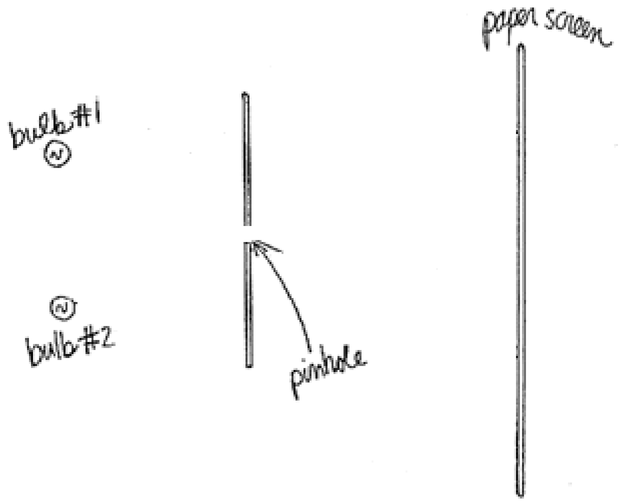
If you are curious about what happens to the light received inside the eye, [you can see the next video.]



1.1. How does light travel?



A.8. Considering the above figure, can you draw the position of the spot of light corresponding to the image of the bulb on the second screen?



A.9. Considering the above figure, can you draw the position of the spots of light corresponding to the images of the bulbs on the second screen?

A.10. Given the two previous activities, which general conclusion can you reach on the propagation of light.

A.11. How can you explain why there is day and night?

Light is born from a light source (sun, light bulb, television…) and travels through space generally in a straight line. All sources of light, except lasers, emit light in all possible directions. Therefore there is light in all the space between the source and the receptor.

Challenge for the most curious students:
Why the moon's reflection in the sea seems to follow us if we move?

A.12. Answer these questions:

a) Do you think the ships see the lighthouse shining with the same intensity when they pass near or far from the coast? Why? Draw the situation including the light rays.

b) Do you think that the light that you can see on the surface of water is the same as deep below water? Why?

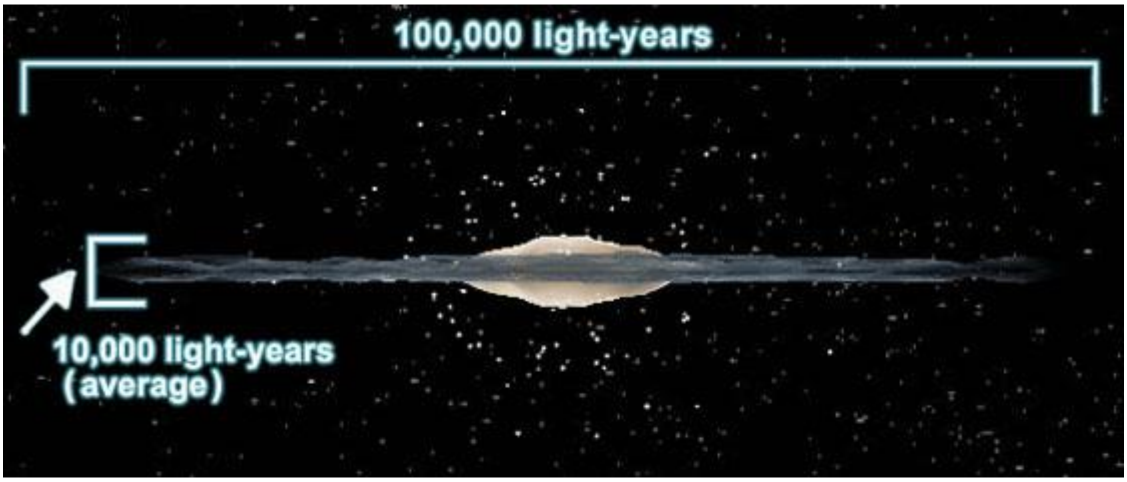
When light travels through space, its intensity decreases because the same light is distributed in a bigger volume.

Anyway if light travels through some material, this material can absorb the light, so its intensity also decreases.

Light travels through space with the fastest speed possible: 300.000 km/s in the vacuum. In the air it's about the same speed. It's an incredible speed. In fact, the fastest possible speed. Nothing can travel in vacuum faster than the light. Can you imagine this speed?

When we have to speak about distances between stars, we need a very large unit of length. We can use the light-year: one light-year is the distance that light travels in a year. Can you imagine this distance?

To imagine light speed, you can visit the next flash animation. Light could travel about eight times around the Earth by equator in a second; it could go around the Sun in about 15 seconds. To imagine a light-year, you have to multiply 300,000 km (the distance travelled in one second) by 31,557,600 (seconds per year).

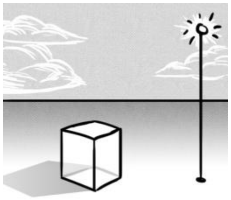


In the picture above you can see the size of our galaxy, the Milky Way, in light-years.

1.2. What are shadows and how are they made?

Bodies have different properties when they interact with light:

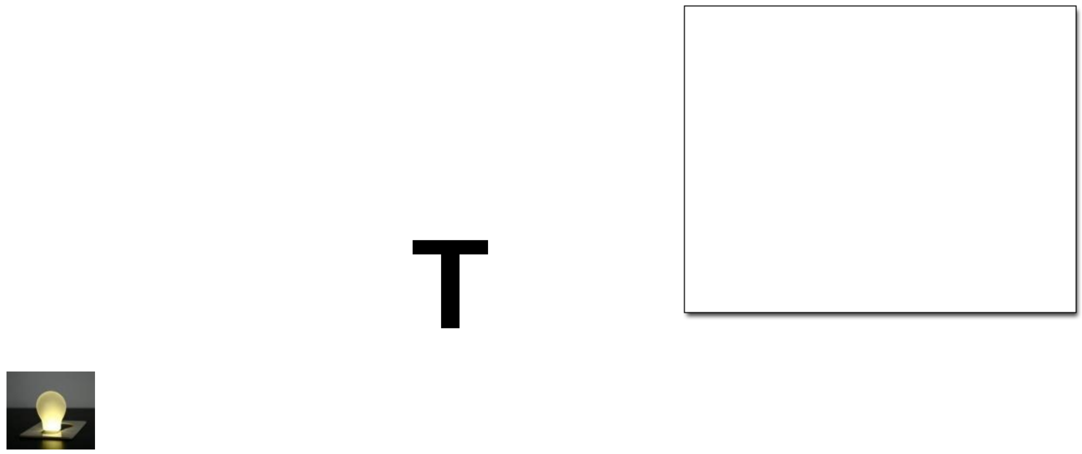
- **Transparent: light travels through the body without change or interaction, so we can see through it.**
- **Translucent: when light travels through the body with some interaction, we can see through it but not perfectly.**
- **Opaque: when light can't travel through the body and we can't see through it.**



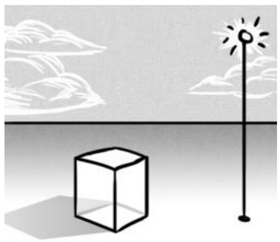
A.13. Explain in the picture above how the shadow is formed. If the body is transparent, can you find its shadow? Why?

A.14. Deduce the Sun's position in the picture above.

A.15. In the picture above, you can see clearly two shadows. Try to distinguish a third. If you remember the night football games on television, sometimes we can see up to four shadows for each player. How is it possible?



A.16. In the picture above, you have a bulb, an opaque letter and a screen. Can you predict the shadow that is formed?



A.17. In the picture above, how do you think the shadow of the object would change if we increase or decrease the intensity of light from the lamppost?

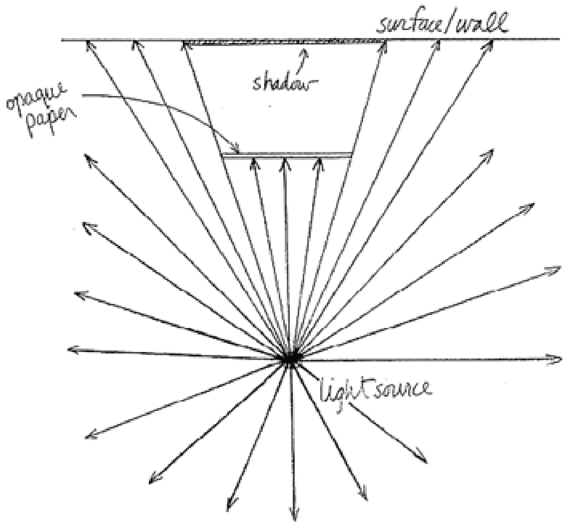
A.18. Considering the situation of activity 16, analyze carefully what variables can affect the size of the shadow projected on the screen. Draw all the different possible situations.

Shadows are made when an object is between an opaque body and a light source. The size of the shadow doesn't depend on the intensity of the light; it depends on the size of the opaque body and its relative position between the screen and the light source.

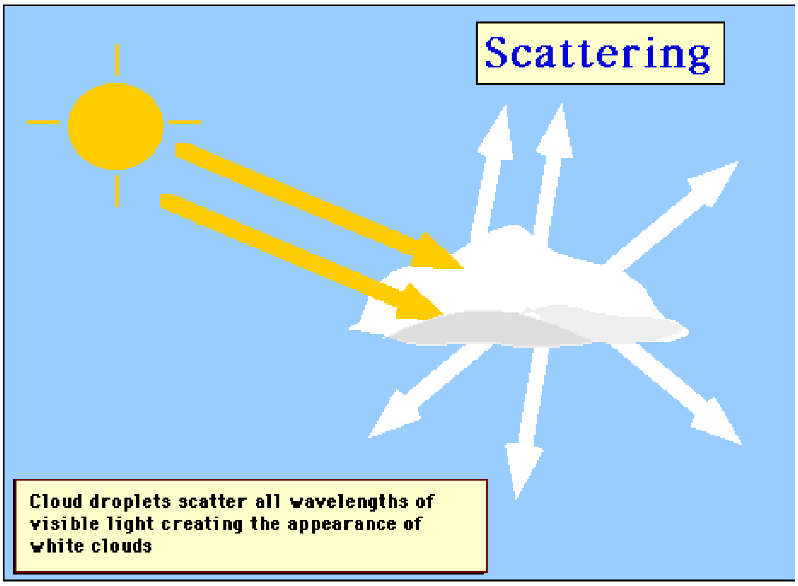
Curiosities about shadow formation:

- Shadow Play.
- Lunar and Solar eclipse (flash animation).
- Lunar and Solar eclipse (video).

- Diagram of the geometry of the shadow formation.

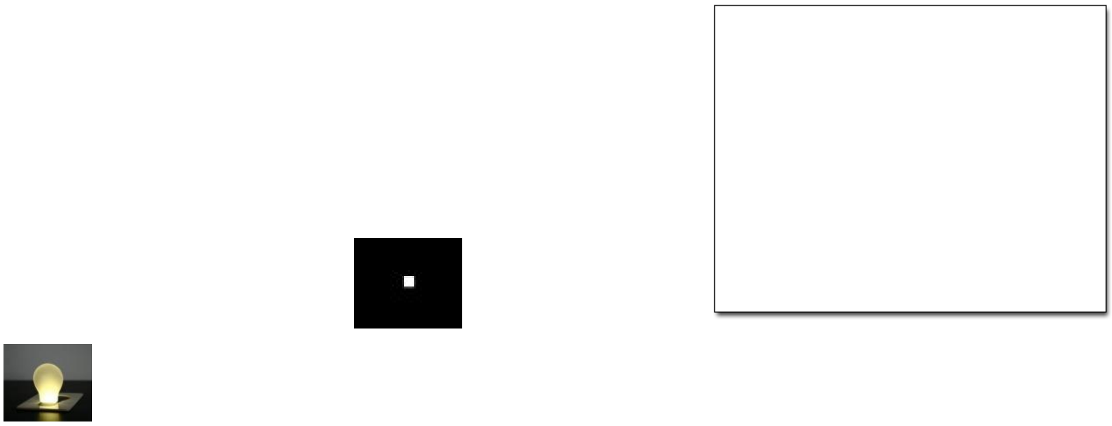


<u>Challenge for the most curious students:</u> When it is sunny, we can observe shadows perfectly well. But if it is cloudy we can't. The next cloudy day, realizes that shadows only remain under the cars. Why?



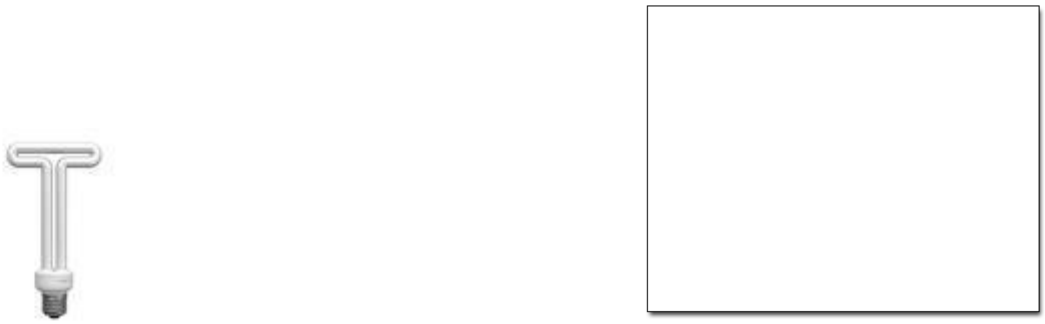
Key: light scattering.

2. IMAGES

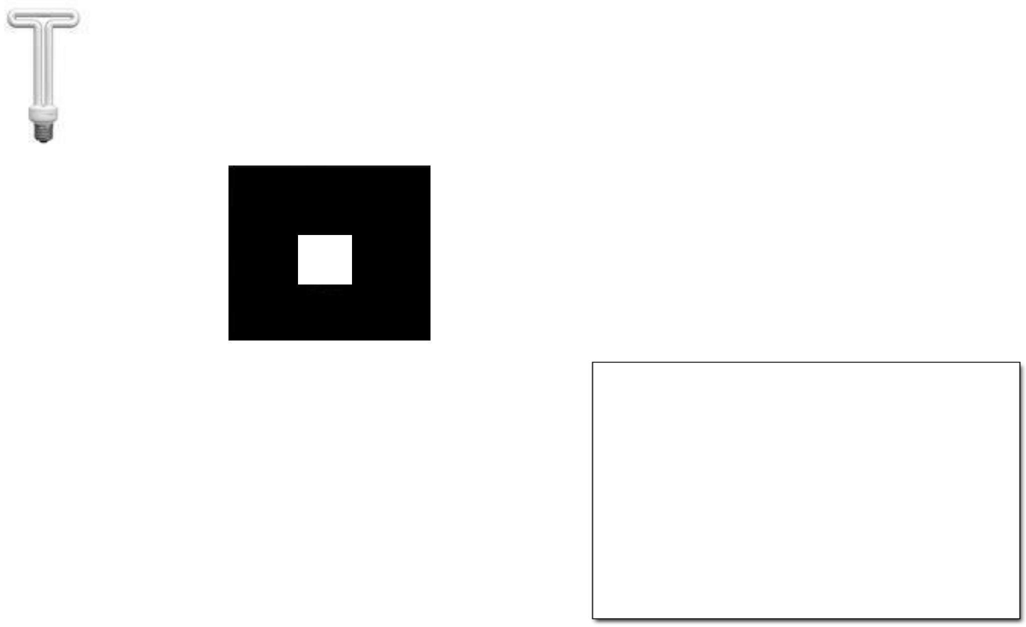


A.19. In the picture above, we can see a bulb, a card with a square hole and a screen. What shape is the image that we can see on the screen?

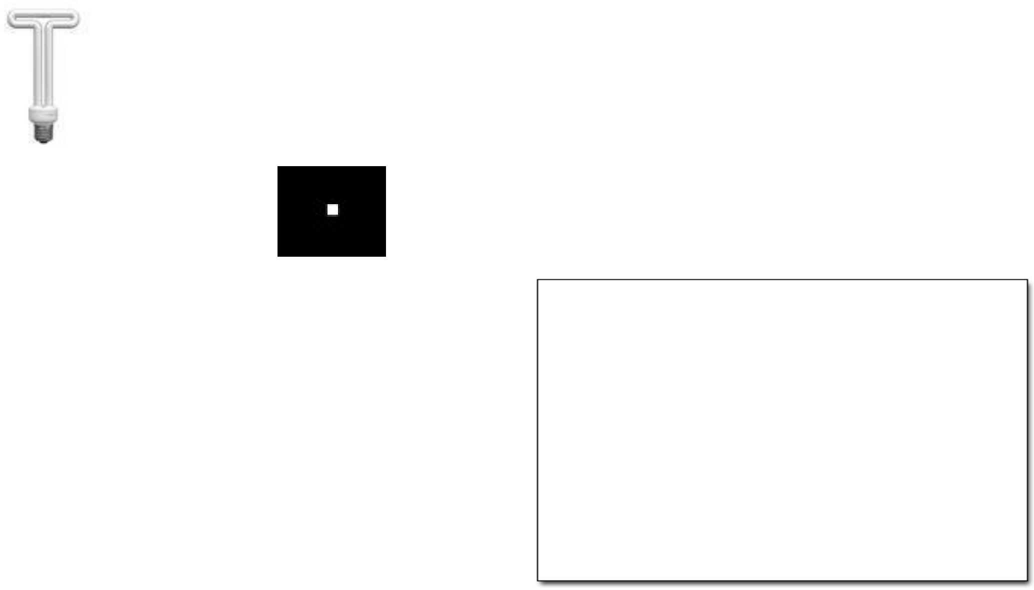
A.20. In the picture below, we have a T shape fluorescent. What do you think we can see on the screen?



A.21. In the same situation, what happens if we put another screen with a big hole in the middle?

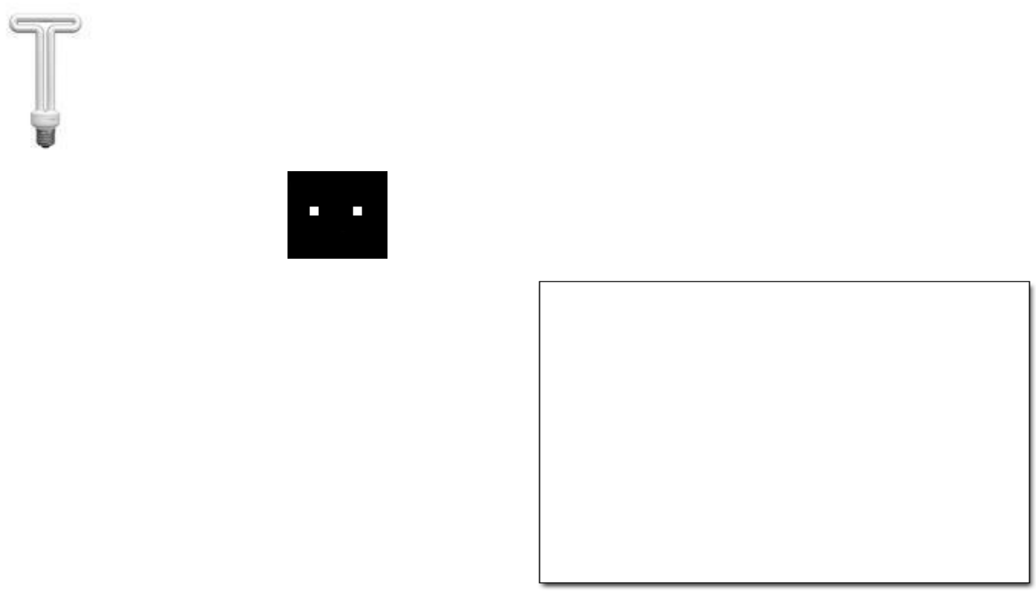


A.22. In the same situation, what happens if the hole in the screen is smaller?



A.23. In the system above, what happens if we cover up half the hole? Could we see only half the letter T?

A.24. What would happen if we make two small holes in the screen?

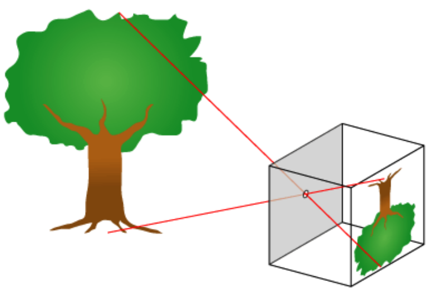


In order to correctly predict situations referring image formation, we must take into account the following principles:

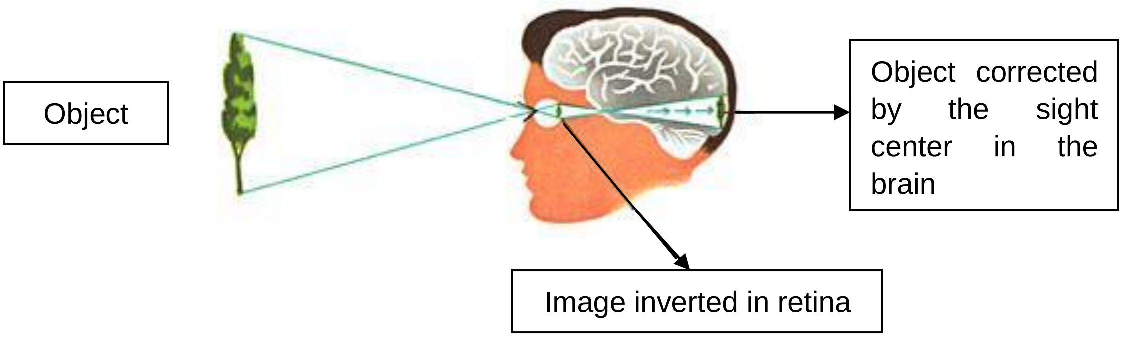
- **Sources emit light in all directions.**
- **Light travels in a straight line.**
- **An object makes an image if every point of the object projects its light on only one point of the screen.**

In the previous activities, we have seen that in some cases we have curious image inversions. We will study more systems where these inversions occur.

A.25. You have to build a dark chamber following the instructions that the teacher will give you. In the dark chamber, images are always inverted, why?



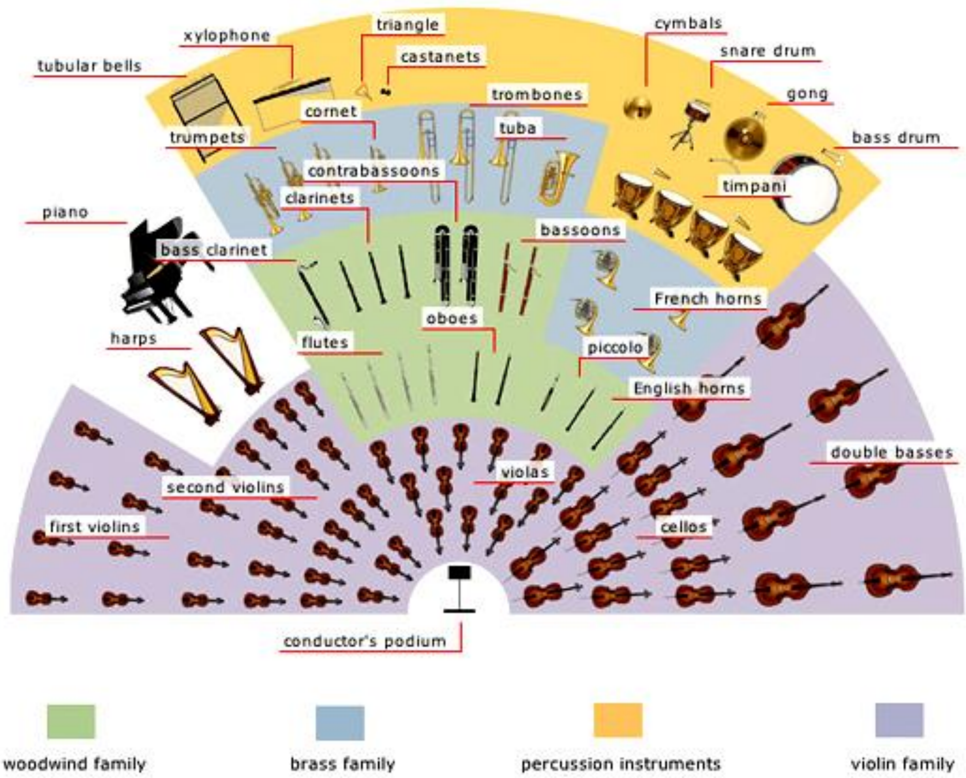
A.26. In our eyes, we have a little dark chamber. Does it mean that we receive images inverted in our eyes? Why don't we see the object upsidedown?



3. SOUND

3.1. Sound qualities

A.27. Listen to different sounds [in the following flash animation] and try to classify them according to different characteristics.



Regarding sounds, we can distinguish three basic characteristics:

- **Intensity: it differentiates between loud sounds and soft sounds.**
- **Tone: it differentiates between high-pitched sounds and low-pitched sounds.**
- **Timbre: it differentiates between sounds of different sources, for example, people or musical instruments.**

A.28. Answer these questions:

a) Listen to different sounds again and try to classify them as loud or soft sounds.

b) Listen to different sounds again and try to classify them as high-pitched or low-pitched sounds.

c) Write different examples of loud and soft sounds or high and low-pitched sounds.

A.29. Look for information on the Internet about the following questions:

a) How can we measure the intensity of sound? What is the scale and the unit used?

b) What are infrasounds? Which animals can perceive these sounds?

c) What are ultrasounds? Which animals can perceive these sounds? Do you know medical applications of these sounds?

3.2. How can we make sound?

A.30. Observe different sound sources like strings, membranes or play a musical instrument like a flute. Can you find some common characteristics of sound production?

Sound is always produced by vibration in a body. In a drum or violin, you can observe vibration directly, but in a flute you can't because the vibration is quicker and it is only in the invisible air.

For perceiving very fast vibrations, you can visit the following video. To see how the sound is produced and broadcast at the molecular level, you can visit the web pages linked.

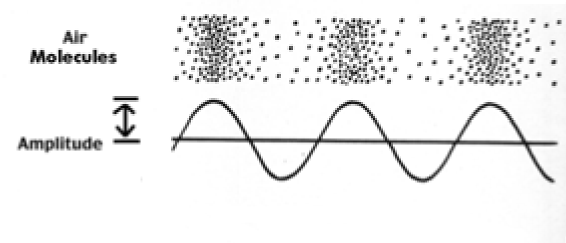
A.31. Answer these questions:

a) With a guitar, how can you achieve stronger and softer sounds?

b) With a flute, how can you achieve stronger and softer sounds?

c) With a drum, how can you achieve stronger and softer sounds?

Sound intensity, stronger or softer sound, is related to the amplitude of vibration which produces it.



To display the change in amplitude of vibration, you can visit the following link.

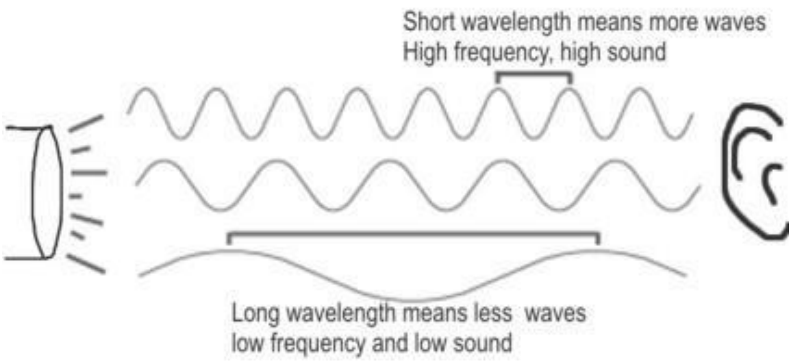
A.32. Answer these questions:

a) With a guitar, how can you produce lower or higher-pitched sounds?

b) With a drum, can you produce sounds with different tones?

c) If you use different drums, do they have different tones?

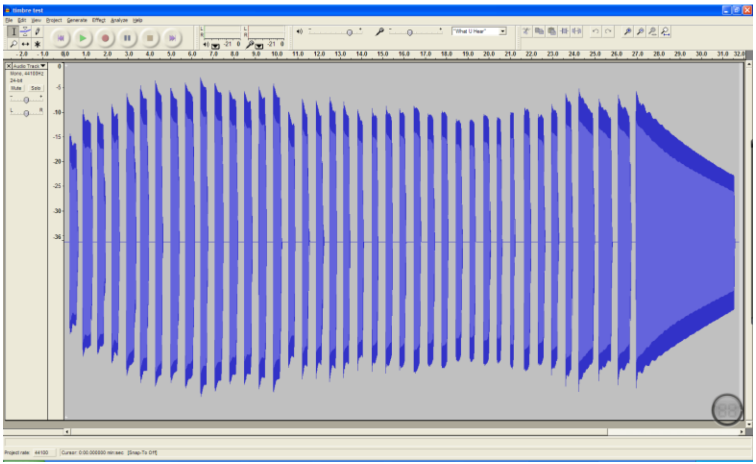
Sound tone, high-pitched or low-pitched sound, is related to the speed of vibration. In scientific language, the speed of vibration is called frequency.



To display the change in frequency of vibration, you can visit the following link. To understand the relationship between vibration and pitch, see the following video.

A.33. When you talk to someone, you can well recognize the voice of every person. Each musical instrument has a distinctive timbre that distinguishes it. What feature of sound do you think is related with timbre?

The timbre is related to the specific form of the vibration which is happening.



In the picture above, you have a diagram that identifies a particular timbre with a particular form of vibration. To display the timbre of different vibrations, you can visit the following link.

3.3. Sound propagation

Sound is produced in a place and we can listen to it in other places, so sound is spread from one point to another.

A.34. Answer these questions:

a) Do you think the sound can be spread in a vacuum?

b) Do you think the sound is spread in a moment or does it take a certain amount of time?

c) Where do you think the sound is spread better, in solid, in liquid or in gas matter? Why?

To compare the speed of sound in different aggregation states of matter, visit the following link.

A.35. Why, in some Westerns, Indians put their ears on the railway tracks?

When we swim at the beach, the boat engines are best heard under water, why?

Vibration is spread better when particles are connected to each other, so it is better in a solid state than a liquid state and it is worse in a gaseous state.

Vibration has a limited speed of propagation, so the speed of sound is fixed: 340 m/s. That means that the sound travels at 340 meters per second in the air. In solids and liquids, this speed is faster.

A.36. Can you know where a storm is, by measuring time between a lightning flash and the sound of thunder? Why?

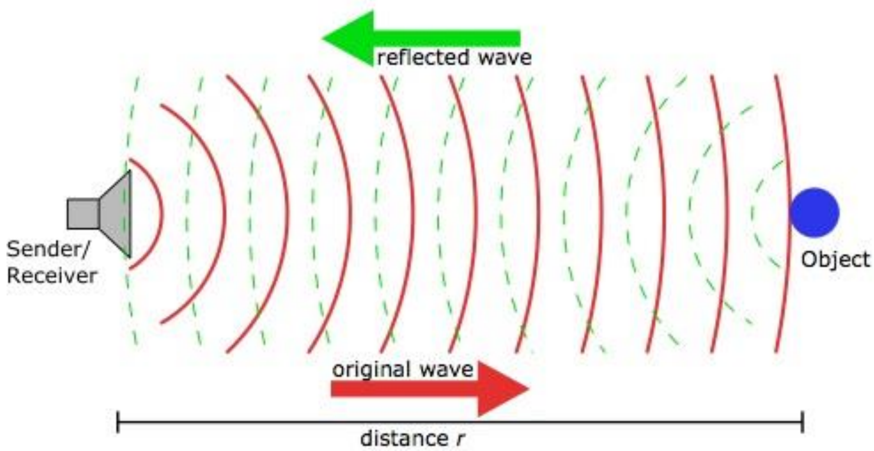
Reflection of sound

Sound is reflected on objects. For example, this reflection allows you to receive sound when it's produced after a door is opened. You don't need see people to be able to hear them.

Reflection of sound produces the echo phenomenon. Have you ever heard the echo? If not, visit the following video.

A.37. Knowing the sound speed in the air, calculate the minimum distance between the sound source and an object so that we can hear the echo.

To differentiate the echo from the reverberation and have an estimated time at which you can hear an echo, visit the following link.



4. SUMMARY

A.38. Try to do a mind map that illustrates and summarizes the whole unit that we have seen.

5. EDUCATIONAL RESOURCES ON THE INTERNET

- The electromagnetic spectrum song.
- The science of light for kids
- How do vibrations make sound? (video).
- Light propagation and measure of time.
- Sound behaviour (video).
- Light Webquest.
- Light Webquest: Let there be light.
- Light and sound Webquest.
- An Internet Webquest on Physics of Sound.
- Sound Webquest.

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http://www.everythingweather.com/atmospheric-radiation/scattering.shtml

http://www.exploratorium.edu/ifi/activities/pinholeinquiry/images.html

http://www.ltscotland.org.uk/resources/s/sound/amplitude.asp?strReferringChannel=learningteachingandassessment&strReferringPageID=tcm:4-606688-64

http://www.ltscotland.org.uk/resources/s/sound/soundingas.asp?strReferringChannel=learningteachingandassessment&strReferringPageID=tcm:4-606688-64

http://www.ltscotland.org.uk/resources/s/sound/soundpulse.asp?strReferringChannel=learningteachingandassessment&strReferringPageID=tcm:4-606688-64

http://www.ltscotland.org.uk/resources/s/sound/speedofsound.asp?strReferringChannel=learningteachingandassessment&strReferringPageID=tcm:4-606688-64

http://www.ltscotland.org.uk/resources/s/sound/waveenvelopes.asp?strReferringChannel=learningteachingandassessment&strReferringPageID=tcm:4-606688-64

http://music.linear1.org/i/timbre-waveform-big.png

http://www.ojodigital.com/foro/paisajes/46513-playa-de-la-concha-serie-de-3-fotos.html

http://www.panoramio.com

http://www.physicsclassroom.com/mmedia/waves/er.cfm

http://www.science-resources.co.uk/KS3/Physics/Earth_and_Beyond/Eclipse.htm

http://www.shutterstock.com/pic-60265480/stock-photo--d-rendering-light-bulb.html

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http://www.youtube.com/watch?v=15P8q35vNHw&feature=related

http://www.youtube.com/watch?v=AUtZdXNtixU&feature=related

http://www.youtube.com/watch?v=dfU0-PBYTQM&feature=related

http://www.youtube.com/watch?v=REqxyVlT45M

http://www.youtube.com/watch?v=xwGs8_otT64

APPENDIX 1: GENERAL VOCABULARY OF THE UNIT

APPENDIX 2: SPECIFIC VOCABULARY OF THE UNIT