Spectroscope

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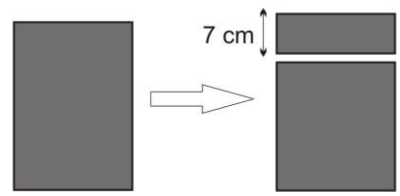
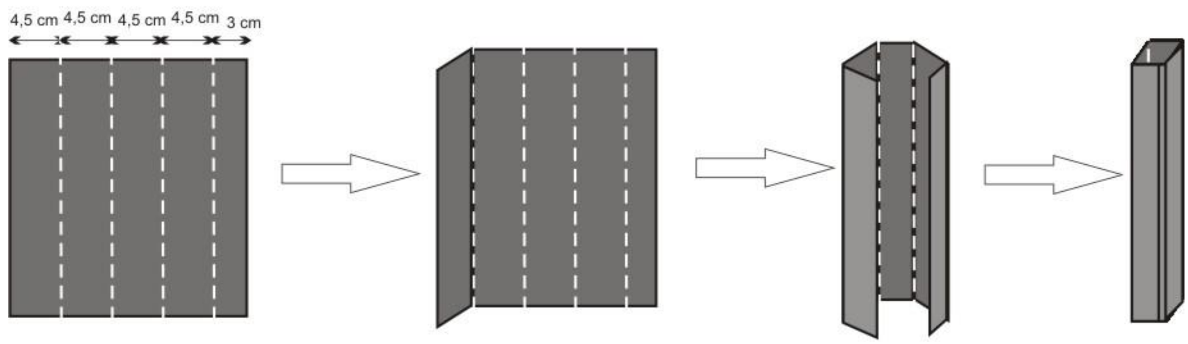
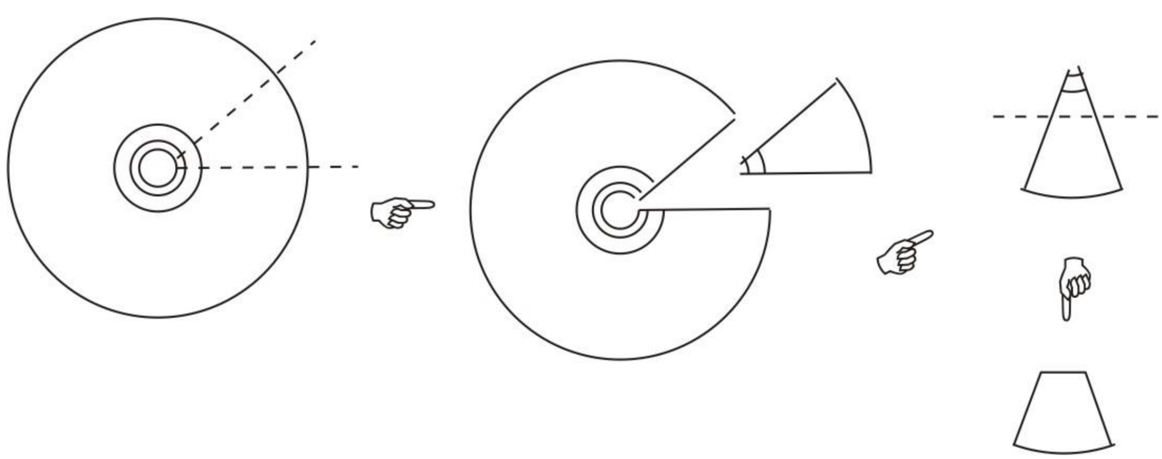
What you need
- 1 A4 sheet from the technical block (black or painted with a felt-tip pen on both sides in black)
- a new or used CD
- a piece of adhesive tape (preferably opaque, e.g. insulating) about 3 m long
- scissors
- a school ruler approx. 20 cm long

A TASK:
Design a spectroscope:
1. Cut a 7 cm wide strip from the top of the paper.
2. Make a cuboid sidewall from the rest of the sheet: starting from the left edge, measure 4.5 cm and fold the sheet inwards. Whenever you finish the forth fold a strip about 3 cm wide is left for the overlap. Glue the overlap with adhesive tape so that the side walls of the cuboid are put together.





3. Cut the fragment from the CD with scissors as follows:

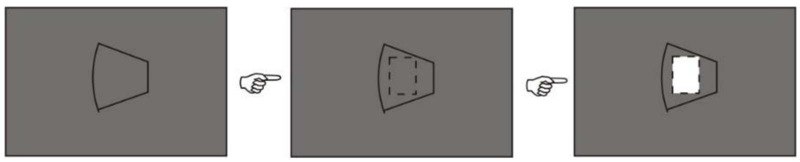


4. Adhere a strip of adhesive tape to the surface covered with this silverware, and then tear it off with the silverware. Stick and tear off the adhesive tape until you get rid of all the silverware.
5. Cut the remaining strip of A4 paper (7 cm wide) in half, separating it into two rectangles. It will be the bottom of your cuboid, but don't stick it yet!

6. In the center of one rectangle, cut a slit ca. 2 mm wide and 3 cm long, parallel to the narrower side of this rectangle:

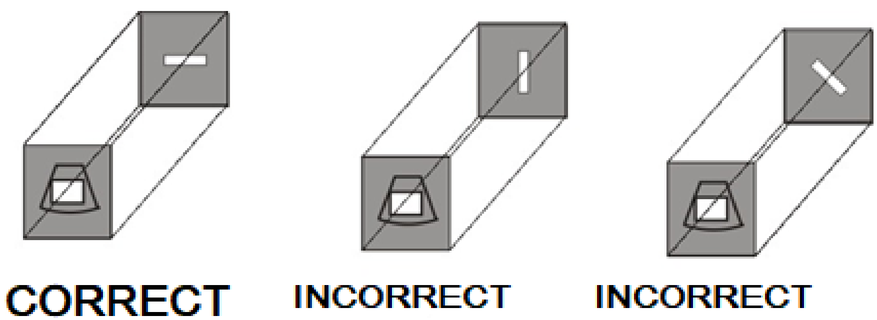
7. Make a the cuboid bottom from this rectangle and glue it to the walls of the previously made cuboid without bases.

8. Place the transparent fragment of the CD cut out earlier and outline its contour. Pu the CD aside and inside this contour cut a rectangular window that does not cross the contour.



9. Adhere the fragment of the CD exactly in the place of the contour drawn earlier, covering the window. Glue the lid formed in this way to the previously made cuboid with its bottom already assembled. After gluing, a fragment of the CD should be placed on the inside wall of the bottom.

Please, note: It is quite important that when looking through the window into the interior of the cuboid, the gap cut in one bottom and the window cut in the other bottom are properly rotated relative to each other:



10. Make sure that light enters the cuboid only through the slit and window. Cover all other clearances with adhesive tape.

That's how you built the spectroscope!

Experiment - Part 1:
1. Point the narrow slit of the spectroscope towards a window lit well by the sunlight.
2. Look into the spectroscope through the window.
Warning: Never look directly at the Sun! Direct the spectroscope at the illuminated sky.
Observation:

1. Can you see two multi-colored stripes on the inside walls of the spectroscope? If not, try to look deeper. Perhaps too much light is coming from the side of the window, so cover the window with your hand (just like when you want to see something in the distance on a bright day), so that the eye and the window are in the shade.
2. Are the spectra you see on both sides similar?
3. Is the spectrum continuous or discrete?

Experiment - Part 2:
Point the narrow slit of the spectroscope towards the lamp with the tungsten bulb (old type bulb).
Warning: Never look directly into the bulb unless it has a cover!
Observation:
Does the spectrum look different than when you watched the sunlight?

Experiment - Part 3:
Point the narrow slit of the spectroscope towards other light sources: fluorescent lamps and lamps with energy-saving light bulbs.
Warning: Never look directly into the bulb unless it has a cover!
Observation:
Does the spectrum look the same as when you watched the sunlight?

Experiment – Part 4:

1. Light on a candle. point the narrow slit of the spectroscope towards the flame and observe the spectrum of the flame.
2. Take an old metal knife. Pour some salt on the knife surface. Place the knife in the middle off the flame. Wait a few minutes. When the salt starts sparkling point the narrow slit of the spectroscope towards the flame.

Observation:
What remarkable difference you can see when you compare the spectrum of a candle flame with a spectrum of a candle flame with evaporating kitchen salt?

Experiment - Part 5:
Point the narrow slit of the spectroscope towards some white fragment of the computer screen.
Observation:
Does the spectrum look the same as when you watched the sunlight? What is the origin of differences?

Physics behind

The light that human being sees as white is actually a mixture of different colors - from purple to red. White light can be split into a multi-colored strip called the light spectrum.

After splitting the white light not always forms a uniform strip in which colors go smoothly from one to the other. The composition of the light depends on the source type.

If the source of light is high density hot matter (e.g. the interior of the Sun or tungsten filament), then its spectrum seen through the spectroscope is continuous. If the source of light is a hot, but diluted gas of a particular chemical element, then after splitting we see single narrow lines, characteristic for this particular element (so the spectrum becomes the element’s “fingerprint”; compare to Bohr’s model).

The spectroscope you built is based **on the transparent diffraction grid.** It is used to split the light reaching the slit into individual colors.

Sunlight and old-type light bulbs seen through the spectroscope split into a full, multi-colored spectrum.

After splitting the light of a fluorescent lamp or energy saving bulb, we see the full spectrum coming from substances covering the inner walls of these bulbs. But against the background of this uniform spectrum we can see also very bright single lines. They come from hot and not dense mercury gas inside the fluorescent lamps or an energy-saving bulb.

When you put table salt into a candle flame, after a short while the salt gets hot, and chlorine and sodium start to evaporate. Spectra of both gases are discrete, however chlorine has got plenty of low-intensity spectra lines, while sodium consists of a few lines, among which a double-line in yellow color is particularly intense. That is why when table salt is popping one can see a distinct yellow line appearing on the full background spectrum of the flame just in the same rhythm as the rhythm of popping evaporation.

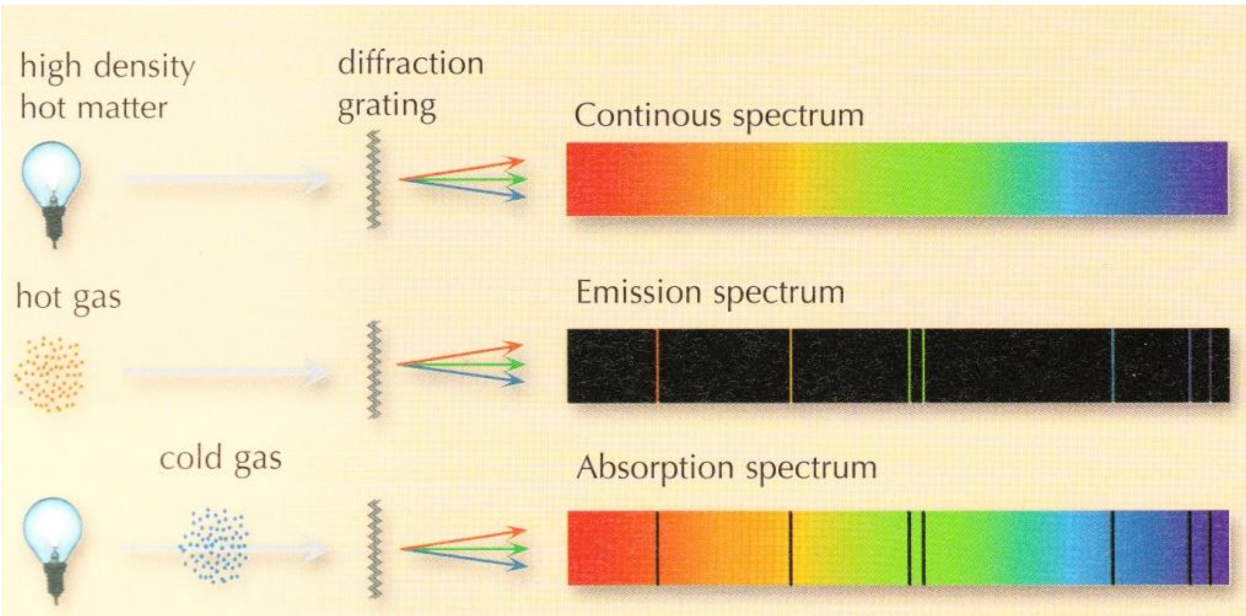


Fig. 1. Three types of spectra and their origin (https://www.scienceinschool.org/2007/issue4/spectrometer)

In turn, computer screens are designed to display any colors as a combination of three basic colors: red (red, R), green (green, G) and blue (blue, B). We call that RGB color system. Therefore, when observing the computer screen with a spectroscope you can see clear, thick lines: red, green and blue. In some screens, you can also see orange or purple (the remaining from the lamp brightening the screen).