How to build a spectroscope

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Suggestions for an activity with the students

I suggest here some logical steps of different activities with the students. I suggest that in all the activities students will work in small groups because all these activities are workshops. This is an ideal progression, and working with a class of "real" students you will face different situations and problems. This should be taken into account, and the activities should be modulated as a consequence.

1.Decomposition of light (from the sun and from different types of lamp) with a prism (the students must answer to question: is it a white light really only white?). They can design and execute an experiment that answers to this question. Observation of the emission spectrum of a light source.

2. Observation of the spectrum of visible light and introduction of wavelength and frequency of the light (light as a wave).

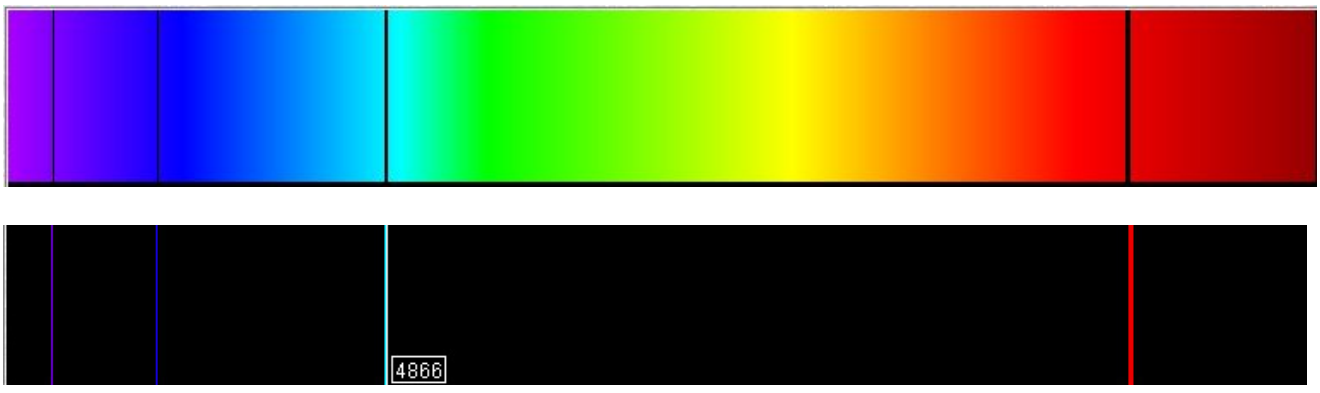
3. Diffraction and diffraction grating (experiment 1): measurement of the wavelength of different colours of the light. In this experiment mathematical concepts are very simple and if your students don't know the trigonometry you can also simplify. (Now you use corpuscular theory. You can chose weather you want to approach corpuscular theory now or later, there is no conceptual problem). You can also continue to utilise the optical bench, so the students can perform measurements; but also they can make qualitative experiments; in any case the construction of a spectroscope permits your students to connect the concepts to a technical&practical experience. It's very important that the students observe light of different sources: a filament lamp, a low power consumption lamp, of a "neon lamp"; and also they will observe the light coming from a gas lamp and "Plucker's tube"; they can also measure the wavelength of the emission lines. (suggest to your students to go outdoors and examine not only the kind of lamp they have at school, at home, but also in their city, and it's very important that they remeber what they noticed and report to the class).

I suggest to use a darken-able room for these experiments, so there isn't superposition of different lights. Only at the end of all the activities you must use different sources of light at the same time and let the students notice the differences.

The students look at different light sources and put in evidence the different spectra so that they can group them.

4. Now you can ask your students (but often the students themselves normally introduce this subject) " What happens to the light if there is an object in between the light source and your eye… ?). The students can make different experiences and deduce "a theory" from their observations. In this case you have to remember that possible "filters" can be solid (as a bottle, a book, a strainer, a sieve..) and also transparent. The students can study different effects on the spectrum (experiment 2). So they can deduce that, through the analysis of a spectrum, we can derive information about the light source and about what there is between the light source and the observer. If the students have their personal spectroscope they can use it for observing many different situations, but it is very important that they remember and report to the class.

5. You can propose to your students to observe the emission and absorption spectrum of hydrogen and ask them to compare these spectra, in order to put in evidence the most important differences. (upper is absorption spectrum).



5. Now you can change the problem: if I have the spectrum of a light source, what can I say about the source of this light? Or in other words: “Astronomers say: in the Sun there is helium, hydrogen…” how do they know this?
You can use an unknown lamp, the students observe its spectrum, they measure the wavelength of spectral lines and they search in website http://jersey.uoregon.edu/vlab/elements/Elements.html the spectrum that is most similar to the one they got from their lamp.

6. You can also propose to your students to observe the spectrum of “neon lamp” and verify if the lines that they see really are the lines of Neon element

7. You can remember Fraunhofer observations, showing a Frunhofer’s picture of the Sun’s spectrum. They can determine

- one or two elements present in the Sun,
- if the Sun’s spectrum is an emission or absorption spectrum,
- if it is an absorption spectrum, then where the absorbing matter is?
- use the spectroscope for observing the spectrum of the Sun and confirm their deductions.

In all activities we use different lamps and we think that they are similar to the stars… this a good model, but real life is much more difficult!

Construction of a spectroscope

A spectroscope permits the decomposition of the (visible) light. A light beam passes through a slit and hits a diffraction grating; decomposition of light creates the spectrum.

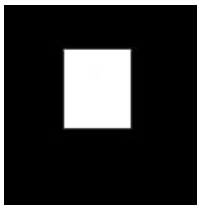
materials needed:

- ✓ paper tube: the inner tube of a toilet paper roll;
- ✓ 2 square black cardboards (8cm*8cm);
- ✓ glue and a cutter;
- ✓ 2 single edge razor blades;
- ✓ scissors, black sellotape
- ✓ diffraction grating (2cm*2cm); this could be a piece cut from an old CD-rom

Procedure:

1. Cut a slit 0.4 cm x 1.5 cm in the centre of one of the square cardboards
2. Fix with sellotape two razor blades together, in a way that their cutting edges are facing one another, with a cardboard only in between (so that the space in between is very thin). In this way you got a very sharp slit.
3. Glue this square to the paper roll. Only when the glue is very dry you can cut the square, so that it'll be just larger than the cylinder base (the tube opening).
4. You can sellotape the borders, in order to avoid any light coming into the cylinder laterally, from anywhere other than the slit.

5. Cut a 1 cm square hole in the centre of the second square card



6. Prepare the diffraction grating: you can cut an old CD, provided you peel out the silvery and coloured film in the upper part of the CD…(be careful, the diffraction grating itself is very delicate!)
7. Fix the diffraction grating square over the squared hole with sellotape on the edges.
8. Glue this square to the paper roll, at the opposite end of the slit
9. Now you can look through your spectroscope, pointing the slit at the source light, with the diffraction grating close to your eye.