Tools for Materials Science - Challenge n°2 - 40'

SEEING DIFFERENT FREQUENCIES

On the desk you have three welding goggles which have been adapted (so they are no more the original ones used for welding), one of them is marked with a red strip of tape.

CAUTION! Careful as you move around with the goggles on! Take care NOT TO bump into anything!

CAUTION! When wearing the infrared goggles, DON'T LOOK AT THE SUN!!!

1. Put the goggles on and look out of the window and around the room.

   Q1. What do you think is happening? What is exactly that you are "seeing"?

2. Now let's have some tests in order to either confirm or reject your hypothesis.

   Test 1
   The goggles NOT marked with the red strip have the visor made with two sheets: a red and a blue filter. The marked goggles instead of these two sheets use a piece of special acrylic plastic (commercial name: plexiglass) whit the same result
   Q2. What's their function? Maybe you can say now what is it that you DON'T see through the goggles…

   Test 2
   Q3. Look at the room lights: what's their colour? Now look at the candle flame with and without the goggles. So what do you think you are "seeing"?

   Test 3
   Q4. Watch the UV lamp (don'tstare into it!): what do you see? Do you think the visor is filtering UV? Test it with the UV reacting beads! If the beads DO NOT turn from white to coloured, then UV radiation is NOT transmitted!

3. Now connect the webcam on the desk to the PC and start Microsoft LifeCam program. The software allows you to take both videos and pictures. This camera has been adapted: the built in IR filter has been substituted with 6 sheets of blue filter plus 6 sheets of red filter (something similar to the welding goggles). However there's a difference:
   Q5. How do you "see" things now? (*suggestions: watch the welding scalpel when you have just turned it off. **BE CAREFUL NOT TO TOUCH IT! IT'S HOT!!!***) Is there still a mix of different reddish hues? Do you think the adapted webcam lets you see exactly the same frequencies as the goggles?

4. Go outside and look around at objects through both goggles and LifeCam: take significant pictures [or videos] and post them in a cartel on the PC with the name of your group.
   Q6. How do you "see" leafy trees and bushes? How do you see the sky? And clouds? Why?
   Q7. What does the different intensity of "white" in the images stand for? What does dark mean? And a very bright light?

OUTPUT WANTED: Answer to Q1, ..., Q7 + at least 3 pictures [or videos] (choose the most meaningful and the most beautiful ones)

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Answer sheet **GROUP N°_____**

Ch.2 --- SEEING DIFFERENT FREQUENCIES

Q1

Q2

Q3

Q4

Q5

Q6

Q7

PICTURES **[*Copied on the PC connected to the Camera*]**

- **Picture1 description:**
- **Picture2 description:**
- **Picture3 description:**
- **[Additional Pictures description:]**

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Teacher's notes

Technical notes:

- **SAFETY NOTE I:** Students will often be walking around wearing special glasses or goggles, making it hard to see where they are walking. You need to be certain that they have a wide-open area where they are free to move around without bumping into anything!
- **SAFETY NOTE II:** When wearing the infrared goggles, be certain that **NO ONE SHOULD LOOK AT THE SUN!!!** Though the goggles reduce the radiation that comes into your eyes, the sun gives off a good deal of infrared, enough to cause irritation.

Organizational notes:

- Each student will keep a copy of the students' sheet but the group will collectively fill in the answer sheet and give it over to the teacher in charge at the end of the lab.

Correction grid

Question or Request	Note	Max. score
Q1	Mostly qualitative answers are expected, so, referring to the key below, mark: - 0 pt. if answer DOES NOT get the point under discussion - 1 pt. if answer just get the point, but not precisely - 2 pt. for full meaningful answer	2
Q2		2
Q3		2
Q4		2
Q5		2
Q6		2
Q7		2
Pic. 1	Meaningful (Yes/No: 1 point); beautiful (Yes/No: 1 point)*	2
Pic. 2	Meaningful (Yes/No: 1 point); beautiful (Yes/No: 1 point)*	2
Pic. 3	Meaningful (Yes/No: 1 point); beautiful (Yes/No: 1 point)*	2

***Pictures**: are the pictures meaningful? [*To evaluate how "meaningful" see also the "Picture Description" on the Answer Sheet*] Are they focusing on significant details or clearly showing the apparatus structure or the investigation results? Are they aesthetically beautiful?

Key to Answers

Q1 - Q3 Use the infrared goggles to see beyond the rainbow (Visible Light Spectrum). Human eyes are actually weakly sensitive to the infrared but once all Visible Light is blocked (red and blue filter) then NIR can be seen as dark red by the human eye.

Q4 It could be considered at first as violet and (near) UV, but actually the goggles filter UV as is demonstrated by the fact that the UV reacting beads DO NOT turn to coloured when they are put under UV screened by the plastic screen of the goggles.

Q5 The camera (plus the software that makes it work !) on the contrary "sees" in black and white: the more intense the IR radiation emitted or reflected, the whiter the object! See the cigarette incandescet tip in the photogallery

Q6 - Q7 When you walk outside and look around what you are seeing is how the world looks in infrared. Plants are almost white; they reflect infrared. The sky is dark; not much infrared is scattered from the sky. Clouds are light coloured (= lots of IR scattering). [*How about clothing? Some things that are dark in visible light are dark in the infrared too; while some things that are light in visible light are dark in the infrared!*]

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What is IR (NIR and FIR)

780 nm to 1mm is commonly considered the range of IR wavelength.

As a rule **NIR** (Near Infrared) – which in the electromagnetic spectrum is immediately before red VIS light –is used in night vision goggles and cameras. However also the human eye is able to perceive NIR provided that no VIS light is around. This can be achieved with a pair of goggles to which red+blue filters have been applied completely darkening the space all around the observers' eyes. Once you get used to darkness it will be possible to see the reddish hue of NIR. To prove that this is not just red reflected light you can focus on a red object: when you wear the googles it will appear totally black!

In the above activity thoug, instead of the blue+red filters a particular IR-transmitting plastic (but not VIS transmitting) is used. More specifically it is ACRYLITE GP, Color #1146-0,which transmits light of wavelengths greater than 750nm. In Europe Acrylite is sold under the commercial name of Plexiglas.

When you talk of IR however you most often think of thermal cameras. Actually they work with **FIR** (Far infrared), also called thermal radiation. Humans and animals, at room temperature, emit infrared radiation in the range of 10 micrometers wavelength. This will be the focus of Ch8_ **TEMPERATURE-&_IR**
In this activity we just took an inexpensive and easy to disassemble webcam (Life Cam), opened it up and took out the IR filter substituting it with 6 sheets of red filter plus 6 sheets of blue filter.This should be enough to ensure that (almost) no visible light reaches the photocamera which therefore will record the world around in infrared! Below a sample of the exploration led by two students.

Photogallery

See also the video IRWorld https://youtu.be/0CWSf_bvH_8

In the above pictures the foliage looks almost white, this is because vegetation reflects IR a lot. The modified camera produces photos in shades from white do dark grey: the darkest spots correspond to no IR reflection/emission, the lighter ones to higher reflectance/emittance areas. On the right the tip of a burning cigarette appears bright white.
The most amazing pictures are taken in total darkness (see below). The first one shows a Bunsen flame : the white area is not just the flame but also the surrounding hot air . On the right you can see the trace of the thermal resistance inside the lab boiler which has been switched on. The resistance is invisible to the naked eye since it is inside the boiler, still the IR camera sees it perfectly! In the video mentioned above you can see the welding scalpel which in compete darkness appears almost white even well after it has been turned off (but its temperature is still very high)!

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The IR google part was inspired by an activity of the Little Shop of Physics, Colorado University http://www.lsop.colostate.edu/

Where to buy

- ACRYLITE® extruded (FF), sheet, Black 9M020 GT - available in US
- **PlexiglassGS Black (all around) 9520GT** -available in EU PLEXIGLAS® Black (232,62 EUR per square meter)[1]

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[1] However the plexiglass alternative now produced is VERY strongly filtering, almost neither IR nor VIS is going through. The multiple sheets of blue and red filters such as Rosco's may be a better option, more easily workable and less expensive.