PHYSICAL SCIENCE

COLOUR

K12 SCHOOLS YOUR EDUCATION PORTAL

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PRIMARY COLOURS (BGR)

* blue
* green
* red

blue + green + red = white

SECONDARY COLOURS (CMY)

(also know as the subtractive primary colours)

* cyan
* magenta
* yellow

cyan = blue + green
magenta = blue + red
yellow = green + red

COMPLEMENTARY COLOURS

Any TWO colours which together give white light are called complementary colours.

Of course, the bgr must be hidden in here!
ANY TWO secondary colours are Complementary colours.

cyan + magenta = white
cyan + yellow = white
magenta + yellow = white

Simply put, Cyan needs ONE more colour to become white. Magenta would do! Hence Magenta would be called the COMPLEMENTARY colour of Cyan.

Important

1. A white object reflects all colours equally well, and absorbs nothing.
* So no matter what colour of light is shone onto such an object, that colour will be reflected, and the object will look that specific colour.

2. A black object absorbs all colours.
* So no matter what colour of light is shone onto such an object, that colour will be absorbed, and the object will still look black.

3. A colourless transparent object transmits all colours equally well.

How can you remember all the colours and their combinations? The letters are in alphabetical order!
EASY!

Write the primary colours as: b - 1 g - 2 r - 3

Write secondary colours as: c - 3 m - 4 y - 5

Now
cyan 3 = 1 + 2 (blue + green)
magenta 4 = 1 + 3 (blue + red)
yellow 5 = 2 + 3 (green + red)

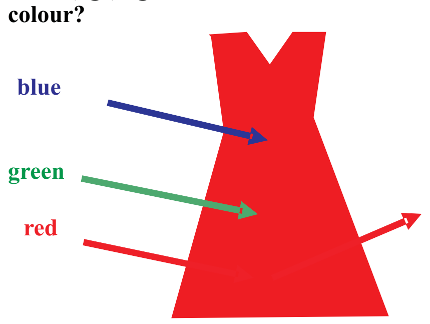
PIGMENTS

Substances such as dyes and paints have a **special chemical** called a **pigment**, that is capable of **absorbing specific frequencies** (colours) of ordinary white light. The frequencies they DO NOT ABSORB are REFLECTED. The reflected colour is the colour we see.

DETERMINING COLOUR OF OBJECTS

Colour Absorption

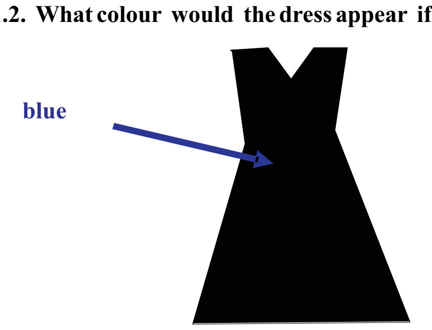
1.1. White (bgr) light is shone on a dress. The dress appears red. What has happened to each colour?



ONLY the red colour is reflected.
Hence the **dress appears** red.

The pigments **ABSORB blue** and **green**.
* blue and green are **subtracted**
* blue and green **cannot** be **reflected**

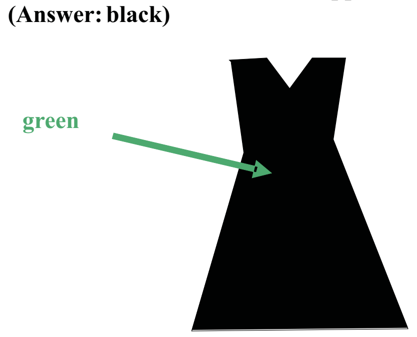
1.2. What colour would the dress appear if ONLY blue light is shone on it? (answer: black)



The **blue** would be **ABSORBED**.
* It is already concluded that this dress absorbs blue.

Since there are NO OTHER COLOURS to be reflected, the dress then appears **BLACK**.

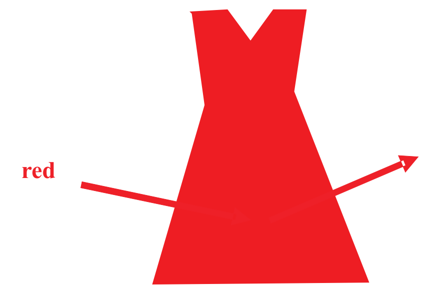
1.3. What colour would the dress appear if ONLY green light is shone onto it? (Answer: black)



The **green** would be **ABSORBED**.
* It is already concluded that this dress absorbs green.

Since there are NO OTHER COLOURS to be reflected, the dress then appears **BLACK**.

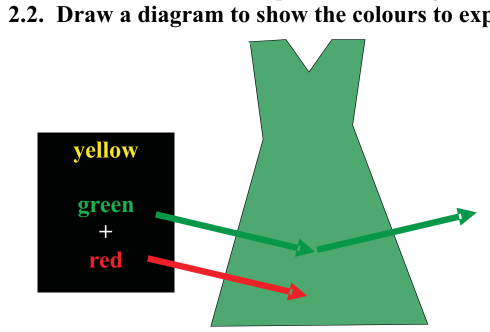
1.4. What colour would the dress appear if ONLY red light is shone onto it? (answer: red)



The **red** would be **REFLECTED**.
* It is already concluded that this dress reflects red.

Since red is reflected, the dress appears **RED**.

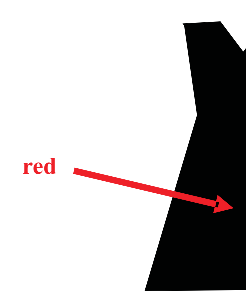
2. Yellow light is shone on a shirt. The shirt appears green.
2.1. What colours make up YELLOW? *green and red*
2.2. Draw a diagram to show the colours to explain why the shirt appears green.



Since the **shirt appears green, ONLY** the **green** colour is **reflected**.

The pigments have **ABSORBED** the red.
* red absorber!

2.3. What colour would the shirt appear if only red is shone on it?



This shirt **absorbs red**! (remember it is already known it is a red absorber)
So the red would NOT be REFLECTED.

Since there are no other colours being reflected, the shirt appears **BLACK**.

2.4. When white light was shone onto the shirt, it appeared cyan.
2.4.1. What are the colours of white light? *blue, green and red*
2.4.2. What are the colours of cyan? *blue + green*

2.5. Does this shirt reflect or absorb blue?
reflects blue since the shirt appears cyan (blue + green), it must be reflecting the Blue, which together with the green, makes the shirt look cyan.

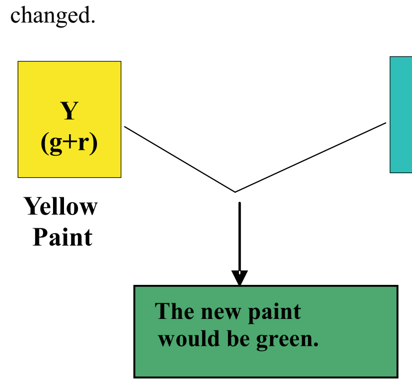
COLOUR SUBTRACTION

Subtractive Colour Mixing

Subtractive Primary Colours: Cyan, Magenta and Yellow

This section is typically for paints and dyes.
A colour of paint may be **YELLOW**, which is a combination of **green** and **red**. This paint is a **blue absorber** since it does not show any blue.

Consider ADDING to the yellow paint, another paint that is CYAN (blue and green). This paint is a red absorber since it does not show any red. The colour of the combination paint is changed.



The **combination colour** will be only the colour **that both paints** can **reflect**, whilst the other colours are subtracted out.

The best way to make sense of this is to set the colours out as shown below.

Paint 1: y = g + r
Paint 2: c = b + g
Common colour = g (green)
The new paint would be green.

Red and Blue are subtracted out.

1.1. What colours do the pigments of yellow paint reflect? *green and red (y = g + r)*
1.2. What colours do the pigments of yellow paint absorb? *blue*

2.1. What colours do the pigments of magenta paint reflect? *blue and red (m = b + r)*
2.2. What colours do the pigments of magenta paint absorb? *green*

3. If equal amounts of yellow paint and magenta paint are mixed, what would be the colour of the new paint?
y = g + r
m = b + r
common = r (red) New paint colour is red.
blue and green is subtracted out.

4. Mix Cyan and Magenta. Would be the new colour?
c = b + g
m = b + r
The common colour is b. Hence the combination paint colour is Blue.
Green and Red are subtracted out.

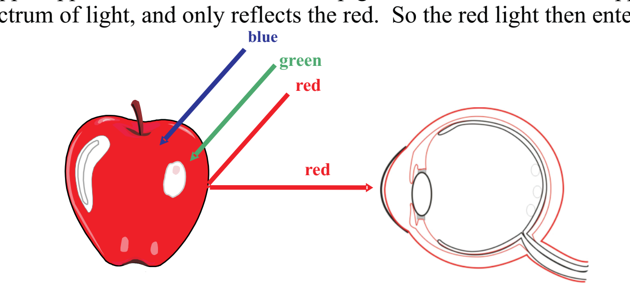
5. Mix Cyan and Yellow. Would be the new colour?
c = b + g
y = g + r
The common colour is g. Hence the combination paint colour is Green.
Blue and Red are subtracted out.

6. Mix Magenta and Yellow. Would be the new colour?
m = b + r
y = g + r
The common colour is r. Hence the combination paint colour is Red.
Blue and Green are subtracted out.

7. Mix Cyan, Magenta and Yellow. What would be the new colour?
c = b + g
m = b + r
y = g + r
No colour is common.
All are subtracted out.
The paint would be black.

EYES AND VISION

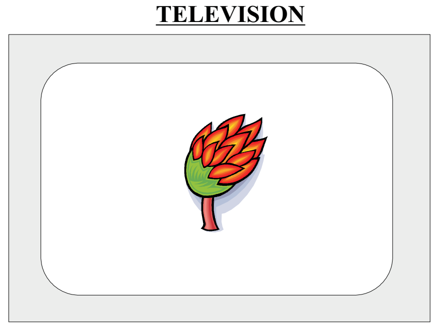
A red apple appears red to us, because the pigments on the skin of the apple, absorbs the rest of the spectrum of light, and only reflects the red. So the red light then enters our eyes.



Retina

1. the retina is a **surface** found at the **back** of the eyes
2. it has **photosensitive cells**
3. these cells are called **rods** and **cones**
4. rods and cells contains **pigments**
5. pigments can absorb visible light
6. **cones** (for **primary colours**) distinguishes between **blue**, **green** and **red**
   - there are three types of cones that are sensitive to blue, green and red
7. different combinations allow for large variety of colours
8. this information is sent to the brain where perception of colour is made
9. **Rods** are for **dim light**, and all objects appear **grey**

TELEVISION



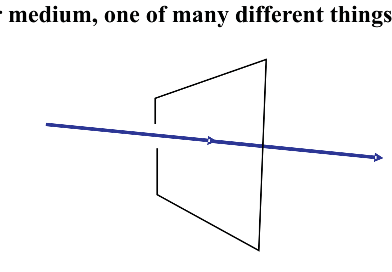
1. colour TV has small dots made of phosphors
2. dots are arranged in triplets
   - one dot for blue, one for green, one for red
3. when struck by an electron beam, they give off their respective colours
4. electrons are fired by an electron gun
5. by electrons being fired at specific dots, pictures are created by the dots producing the three colours
6. these colour beams then enter our eyes
7. Hence we see the picture

TRANSMISSION AND SCATTERING OF LIGHT

Consider UV and Visible radiation
When UV and Visible light strikes another medium, one of many different things can happen.

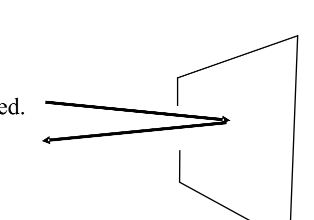
A. Transparent Non-metal
- Light will pass through it.

This is called transmission

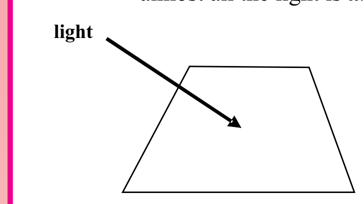


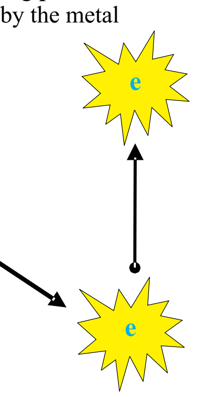
B. Coloured Opaque Non-metal
- Some light will be absorbed, rest reflected.

This is called reflection.



C. Metal (absorb energy, release energy)
- Light will be reflected by the following **process**:
  * almost all the light is **absorbed** by the metal

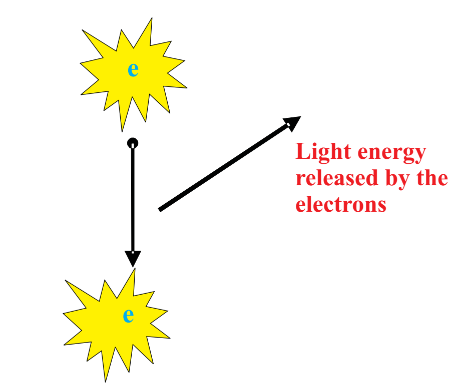




* this light causes **delocalised electrons** in the metal **to rise to higher energy levels** within the atom

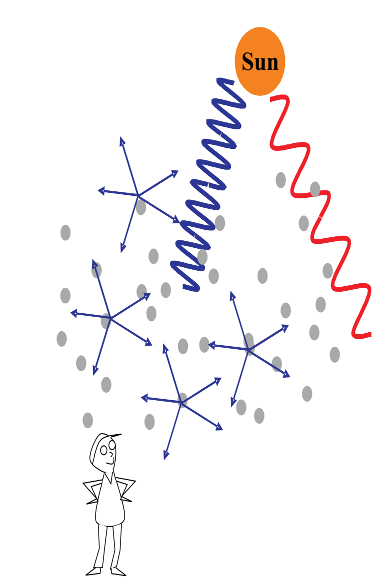
▪ when the **electrons fall back** to their original levels, they **give off** the **energy** they had previously absorbed **in the form of light**

- **This is the reason metals appear shiny.**



D. Gas (Scattering) *(Also known as Rayleigh Scattering)*
- Gas molecules are very small.
- The atmosphere is mostly nitrogen and oxygen.

Daytime
When white light from the sun enters the atmosphere, the blue light is most affected by the presence of the gas. The reasons for this is as follows:
* **blue** (high frequency) has a **very small wavelength**
* the **gas** particles being **small too**, are able to **scatter** the **blue light**
* the blue light is scattered in all directions by the gas molecules
* this scattering of the blue light **makes the sky blue** during the day since the **blue light** Will appear to be **coming from everywhere**



Gas molecules scatter the blue light, making blue appear from everywhere. The whole sky appears blue.
Red light, due to its **larger wavelength**, is **not affected** by the size of **gas molecules**, and is **not scattered**. Hence you do not see the red light. The red light **just passes through** the **atmosphere**.

Sunrise and Sunset
- **The Sun is now lower in the sky to you.**
- **Light has to travel a much greater distance to reach you from the Sun**
- **Air molecules have scattered and rescattered the blue light much more, so much more, that you cannot even see the blue anymore!**
- **This allows the red light to now be easily observed since the blue light is "out of the Way".**
- **Hence the sky now looks red.**

E. Clouds
- when visible light hits "**larger**" objects i.e. **objects** that have a **larger size** than the **wavelengths** of the light, **all** the light is **reflected** in **all** directions.
- the reflected light still looks white since all the light is reflected, not just specific colours.
- this is why clouds look white