Cartographic polygraphy and reprography

Color reproduction

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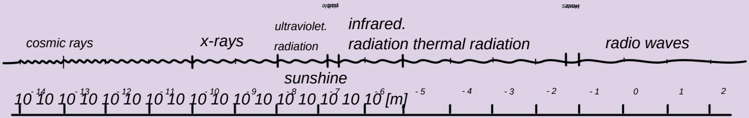
Light

Physical essence

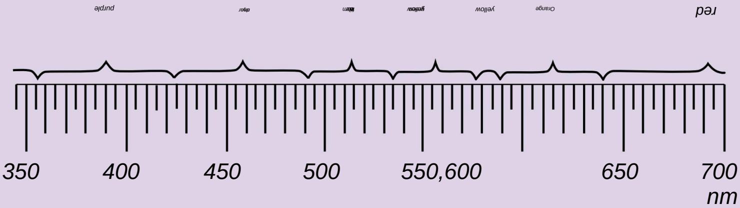
- **Maxwell** (electromagnetic field) - part of the radiant energy emitted by bodies and causing a sensation - vision on the retina of the human eye
- **Planck** (quantum theory) – light energy emitted in bursts

Electromagnetic spectrum

A brilliant spectrum



Visible spectrum

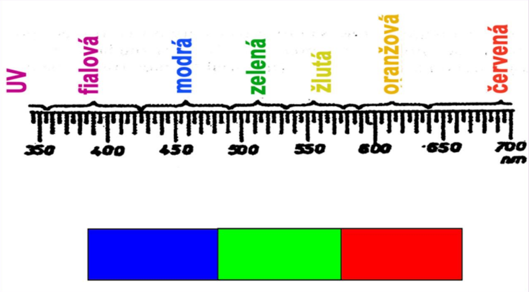


Basic colours

RGB

When the brightness decreases, three main broad spectral bands can

- be observed: blue (B – Blue) in the range 400–490 nm green (G
- – Green) in the range 495–565 nm red (R – Red) in the range
- 640–750 nm



Color perception

The principle of vision

- Human **color vision** consists in the analysis, evaluation and encoding of information that the eye obtains from a **color stimulus.**
- By processing the stimulus in the brain, the information becomes a **color perception.**
- **The image** in the eye is created on the **retina** equipped
  - with: **cones** for detecting basic colors **(RGB)**
  - **rods** for the perception of color intensity (we perceive the image as black and white in the dark)

Color perception

Color perception

The eye perceives:

- **hue** - color tone - corresponds to the wavelength of light reflected from the object **saturation** - color saturation - colors have the
- highest saturation spectral **brightness** - lightness of color - decreases as light
- intensity decreases

HSB color system

The HSB system is the most natural to human perception, it includes:

- **H (Hue)** – shade of color
- **S (Saturation)** – color saturation (100% for spectral colors)
- **B (Brightness)** – color brightness

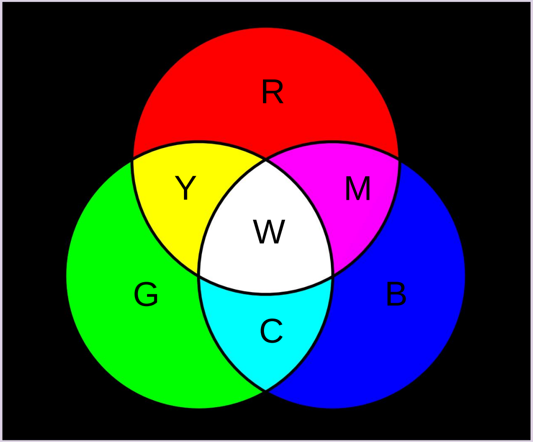
Additive color mixing

Color system RGB

- basic colors R, G, B
- numerical values in the range 0 to 255 (8 bits -
- 28), multi-bit coding possible
- **spectral** colors (fully saturated colors) have a value of
- 255 more than 16.7 million colors can be expressed
- (2563) used for input devices (scanner, camera, monitor)

Additive color mixing

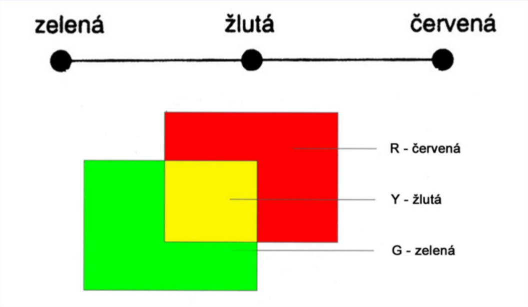
Principle



Additive color mixing

Color hue

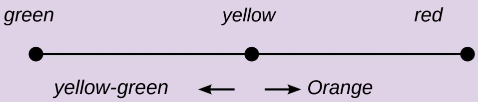
Additive color mixing at the same light intensity of two projectors (R, G).



Additive color mixing

Shade of

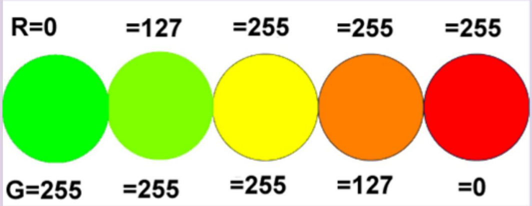
color When one of the projectors is **shaded** with green or red colors, **yellow-green** or **orange colors will be produced.**



Additive color mixing

Mathematical expression of the color

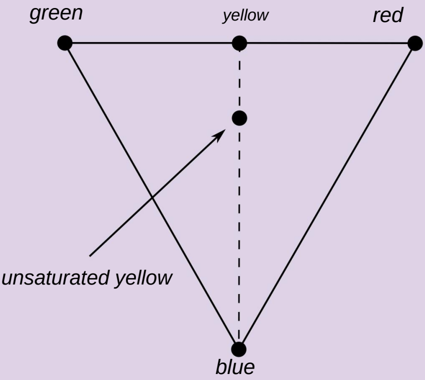
shade **Additive mixing of the saturated base color R and G** results in a **saturated yellow color.**



Additive color mixing

Color

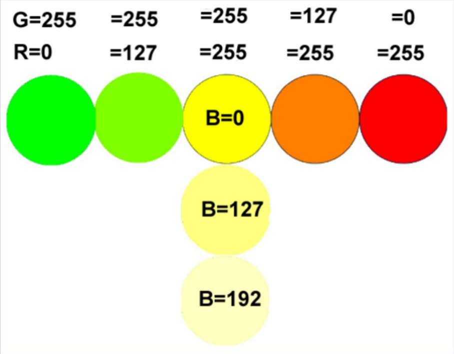
saturation **Rich** (saturated) colors are spectral colors that are located on the perimeter of the triangle - the saturation decreases towards its center (white).



Additive color mixing

Mathematical expression of color saturation The

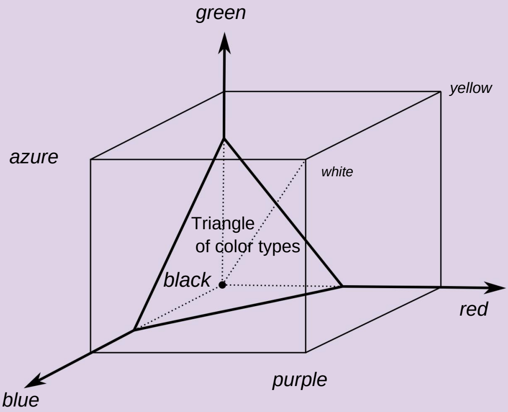
saturation of the yellow color is reduced by adding the values of the blue color (B).



Additive color mixing

Color

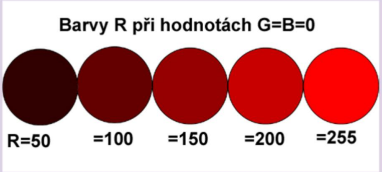
brightness Color **brightness** (lightness) decreases when light intensity decreases - it can be expressed as a spatial color body.



Additive color mixing

Mathematical expression of color

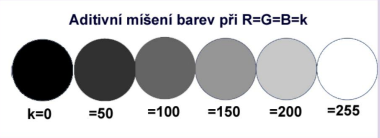
brightness Spectral colors have the highest brightness, e.g. red at a value of R=255.



Additive color mixing

Mathematical expression of gray

color By additively mixing all three basic colors with the same saturation **k,** we obtain **a scale of gray colors.**



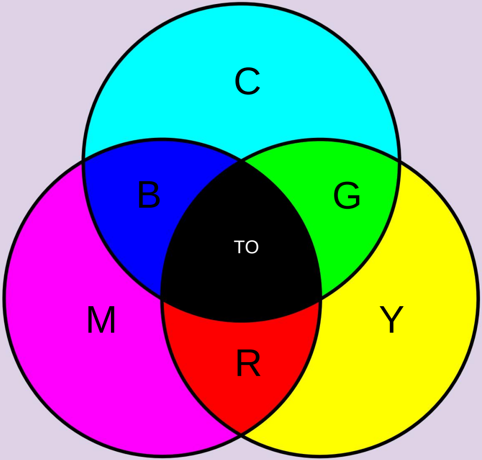
Subtractive color mixing

CMYK color system

- from the set of wavelengths of light, the wavelengths of complementary colors are subtracted, complementary colors
- are used when printing: C – Cyan (cyan), M – Magenta (purple),
- Y – Yellow (yellow), K – Key (black, key) the amount of color indicates in percentages (0-100%) the subtractive mixing of
- saturated complementary colors results in reverse basic colors
- (RGB)

Subtractive color mixing

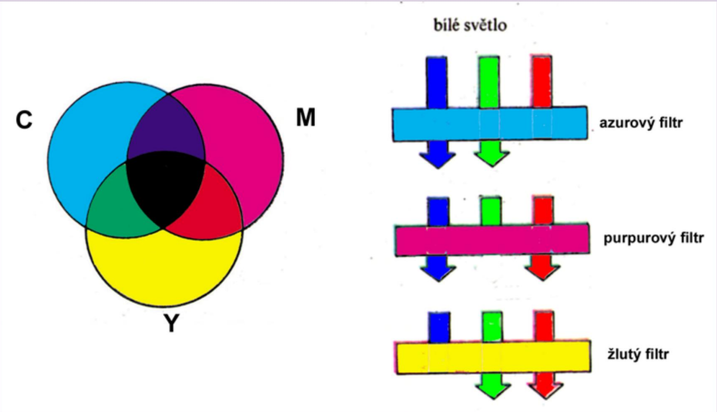
Principle



Subtractive color mixing

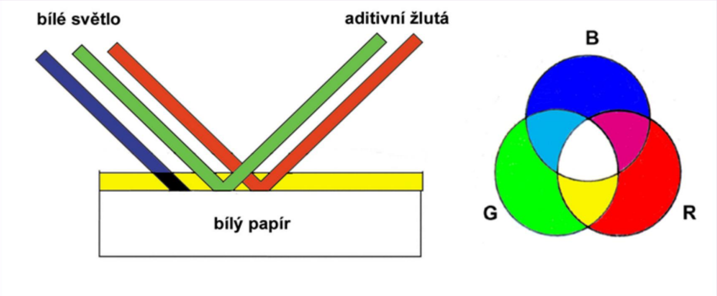
Color filters

Printing inks act as color filters.



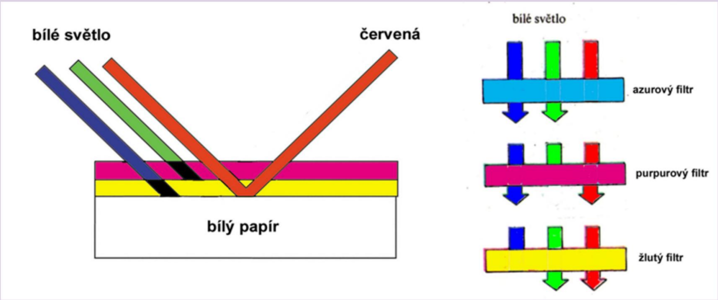
Subtractive color mixing

Perception of the color yellow



Subtractive color mixing

Perception of the color red



Other color systems

CIE LAB

- **Standard color table CIE** (Commission Internationale de l'Eclairage) - 1976, based on imaginary basic colors marked XYZ (corresponding approximately to RGB).
- Color description is provided **by the CIE L*a*b* color system** (uses lightness, hue and saturation).

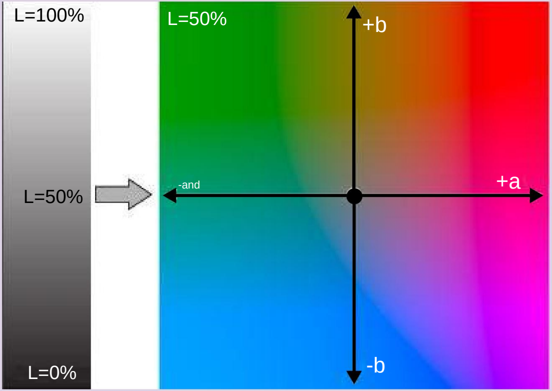
Other color systems

CIE LAB

- The system uses **color pairs** (red-green, yellow-blue, black-white) that are based on the vision and perception of color by the human eye.
- Hue and saturation create **a chrominance plane,** colors are defined by coordinates **a*b*,** which can take values from ÿ90ÿ to +90ÿ .
- The brightness L* takes on a value of 0% to 100%.

Other color systems

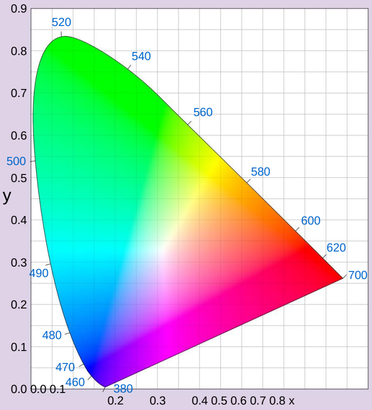
CIE LAB



Chromaticity diagram

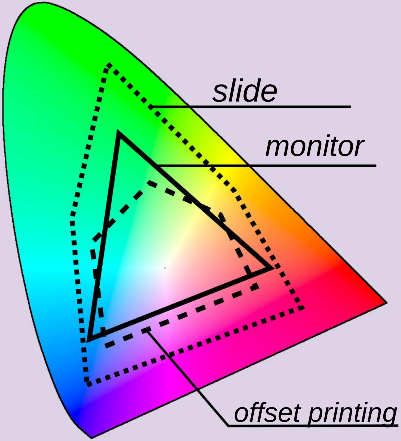
CIE

xyY Set of all visible colors. The connector of two colors contains all shades that can be created by mixing them.



Color gamut

Color presentation ability



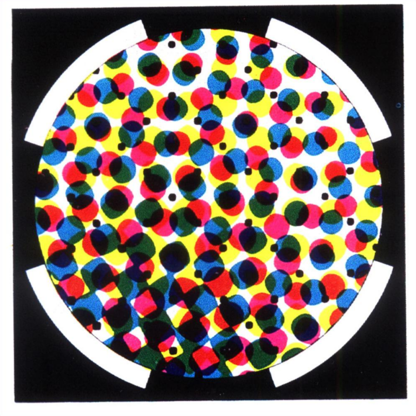
Color gamut

Color gamut

- Color presentation capability is dependent on the device used.
- Colors outside the gamut are replaced by other (reproducible) colors.
- When printing, the gamut can be expanded by adding additional printing colors (usually green, violet or orange) - e.g. hexachrome is used instead of CMYK four-color printing.

Overlapping of networked campuses

Overlapping of networked campuses



Reproduction of a color original

Task

- color original (map, orthophoto, photograph, . . .) creation
- of color faithful copy – facsimile (analog x digital process)

Original

- digitalization solution (resolution)
- original modification (retouch, color correction)
- original reproduction (cost, printing method)

Equipment

Equipment for working with paint

- scanner (table, drum) digital
- camera (DSLR – Digital Single Lens Reflex) monitor (CRT – Cathode
- Ray Tube, LCD – Liquid Crystal Display) printer (inkjet, laser, ...) printing machine (offset, digital printing, .. .)
-
-
- PC – hardware and software (graphics card, operating system)

Color measurement

Machines

For objective color measurement, the following is used:

- colorimeter
- spectrophotometer

Colorimeter

- the sample is illuminated by a standard light source the
- reflected light is filtered through three color filters its
- intensity is measured by the voltage on the photodiodes
- the RGB values of the sample are obtained less accurate
- than a spectrophotometer

Color measurement

The spectrophotometer

- measures in individual parts of the visible spectrum (380–730 nm) with a
- measurement step of 5 nm or less
- comprehensive overview of the spectral composition of
- color manual x automatic spectrophotometer can be
- profiled and LCD displays can distinguish metamerism
-

X-Rite ColorMunki

Properties

- profiling of monitors, RGB and CMYK printers,
- creation of ICC profiles, connection to a PC via a
- USB port, the possibility of transferring measured
- values (e.g. to Photoshop or Gimp) capturing colors directly from the screen or printed material
-

X-Rite ColorMunki

Use

Metamerism

Metameric colors

- of a color with a different spectral composition can be visually perceived as the same color due to the lighting or the observer the
- effect of lighting - different lighting leads to the distinction of colors the
- effect of the observer - a different observer differentiates the colors
-

Color matching

Color deviation ÿE CIE

- LAB color space
- the difference of two colors ÿE
- ÿE = ÿ ÿL 2 + ÿa 2 + ÿb 2

Perception of color deviation

ÿE	**color**
< 0.2	**difference**
0.2 – 1.0	imperceptible
1.0 – 2.0	perceptible
2.0 – 4.0	discernible not
4.0 – 8.0	yet disturbing
> 8.0	slightly disturbing distu

Color management system

Color Management System – CMS Color

management is of fundamental importance in the field of polygraphy. Task: ensure the maximum possible color matching

- in the reproduction process Solution:

1 determine true colors for input device RGB values 2 preserve true colors when transferred between devices

Color management system

Components

1. Device profile - RGB (CMYK) ÿ CIE LAB (CIE XYZ)
2. Profile connection space (Profile Connection Space – PCS)
3. Color Management Module (CMM) – color conversion program
4. Gamut recalculation method (also rendering method) - method of rendering colors outside the gamut

Device profile

ICC profile

- assigns RGB or CMYK values of the device to a color in the CIE LAB or CIE XYZ space describes the color space
- of the device, its gamut and color reproduction behavior ICC (International Color Consortium) – standardization of the profile
- structure ICC specification defines the format of the profile file – ICC profile implementation of the profile in the form of a lookup
- table (only samples - the rest will be calculated by CMM)
-

ICC profile

According to the scope

- of use for a specific device - differences between products of the
- same model for a specific device model - a generic profile for an
- abstract color space - e.g. sRGB, Adobe RGB, etc.

By device type input

- device profiles display
- device profiles output device
- profiles

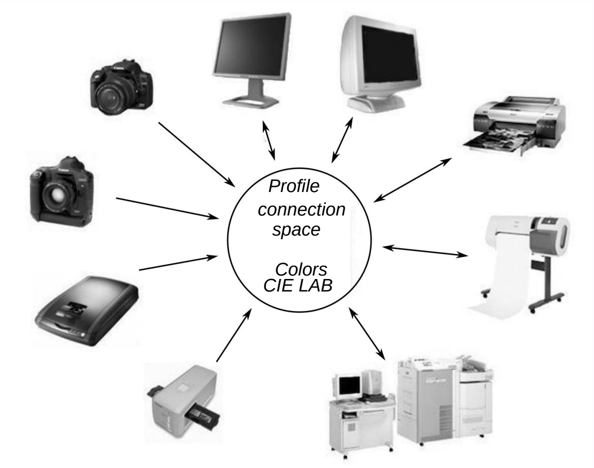
ICC profile

Use

- color conversion from one device to another (using PCS) 1st
- device – source profile 2nd device – target profile monitor –
- both output and input devices (editing according to visual
- impression) output device – also in the role of input device (simulation of printing on another device)
-

Profile connection space

PCS



ICC profile

Creating a profile

- equipment: device for measuring colors, specific color templates and software procedure: 1 – calibration of the device, 2 – profiling
- (characterization) of the device
- calibration - setting the device to a stabilized state with the best profiling results - custom creation of an ICC profile (depending on
- the type of device)

Creating a profile

Profile of the input device

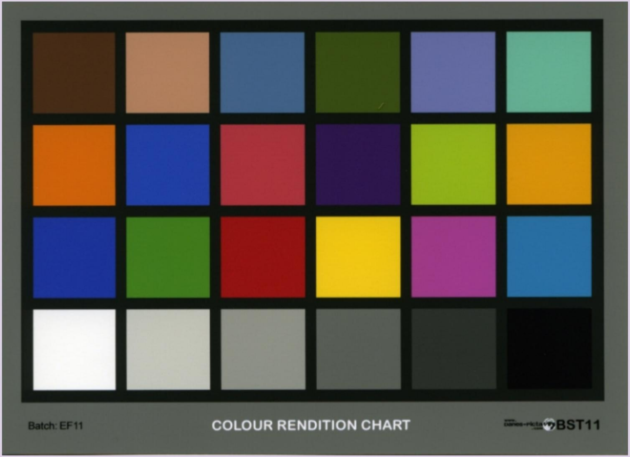
- calibration – suppression of all functions of the scanner or camera (noise suppression, sharpening, etc.) profiling – a standardized
- test sample (target, target) and a reference file with the color values of the sample are sufficient, the sample is scanned or photographed
- by comparing the obtained data with the reference file, a program
- is created profile profiles are made separately for reflective and transparent templates
-

Creating a profile

A target for profiling scanners

Creating a profile

Target for profiling digital cameras



Creating a profile

Display device profile

- calibration – adjustment of brightness, contrast, white point temperature and gamma value profiling approximate – in a visual
- way (insufficient for professional purposes) profiling accurate – using a measuring device on the monitor the program gradually
- sends known RGB values to the monitor the device measures the
- colors displayed on the monitor modern LCD monitors have larger
- gamut than CRT monitors
-

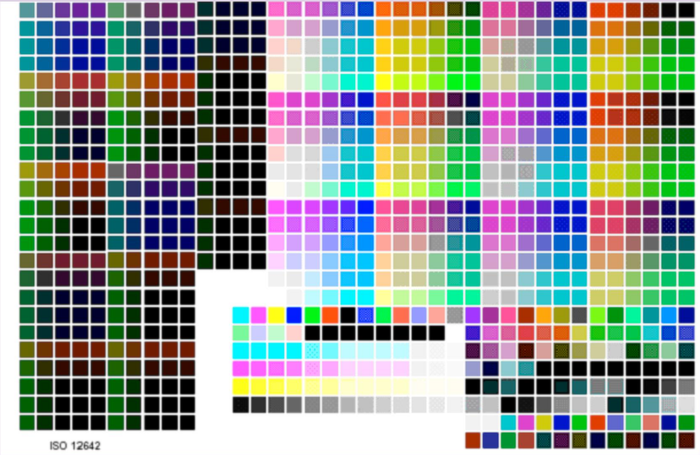
Creating a profile

The most complex output

- device profile – describes the device, the paper used and
- the colors calibration – specific to the type of device
- profiling – a standardized master is printed the colors of
- the printout are measured and compared to the reference values
- output device profile types – RGB, CMYK, Hexa Color (e.g. Pantone Hexachrome, CMYK+OG) profiles standardized by the standard (for
- technology, printed material, colors), e.g. for FOGRA offset according to the ISO standard 12647-2

Creating a profile

Target for profiling output devices



Practical use of color management

Schematic procedure

- use an application with color management support (DTP area)
- assign (or insert) a color profile to each graphic file edit the color folder of documents on the profiled monitor
-
- use the profile of the output device when printing

Publications

Basic resources

- Fraser, B., Murphy, Ch., Bunting F.: Color Management - The Graphics and Pre-Press Professional's Guide, Computer Press, 2003, ISBN: 80-7226-943-7
- Dvoÿáková, Z.: DTP and prepress preparation. The complete guide from graphic design to professional printing. Computer Press, as Brno, 2008. ISBN 978-80-251-1881-8 Bann,
- D.: Polygrafická poudska, Slovart, Prague, 2008, ISBN: 978-80-7391-029-7