Southwestern Graphics 1995

Color Theory & Reproduction

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Additive vs. Subtractive

- Additive Color is used in photography, television, and computer monitors.
- Subtractive Color is used with pigments, such as paint or ink.

Communicating about Color

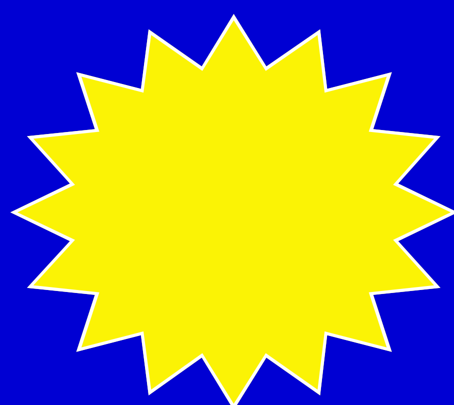
- Printers and buyers need to understand that color systems impact the way a colored object appears.
- Objects created using different color systems will look different – no matter what!

Start at the Beginning

- Color comes from light.
  - Without light there would be no color.
  - If you doubt this, try viewing color in a room without light!
- Objects do not "have" color.
  - They can either reflect or absorb the light that strikes them.

Sources of Light

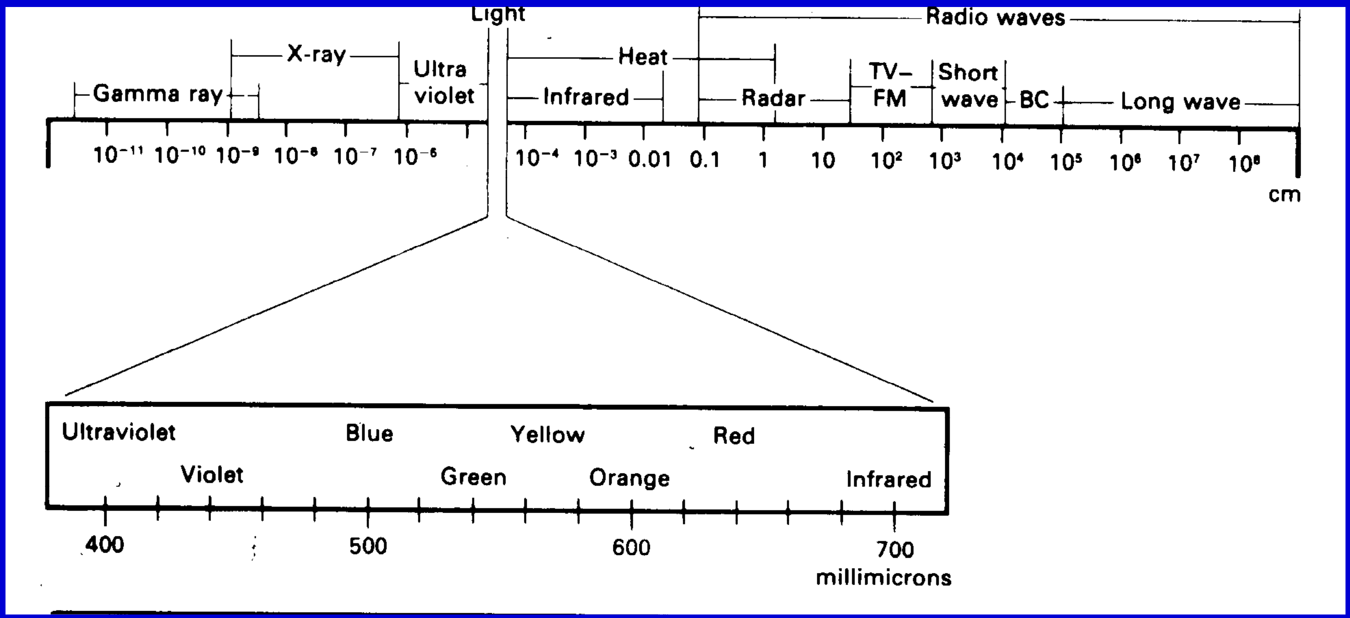
- All light originates from the sun.
- “Natural” light comes directly from the sun.
- “Artificial” light usually comes from the burning of some solid or gas.



Natural Light

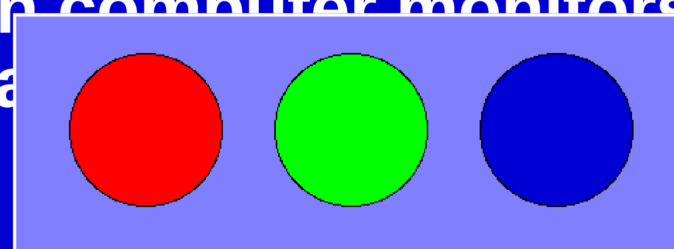
- The sun gives off many different waves of electromagnetic energy.
- Humans can see, hear or feel waves of different lengths.
- The sun’s waves are arranged by length in the electromagnetic spectrum.

The Electromagnetic Spectrum



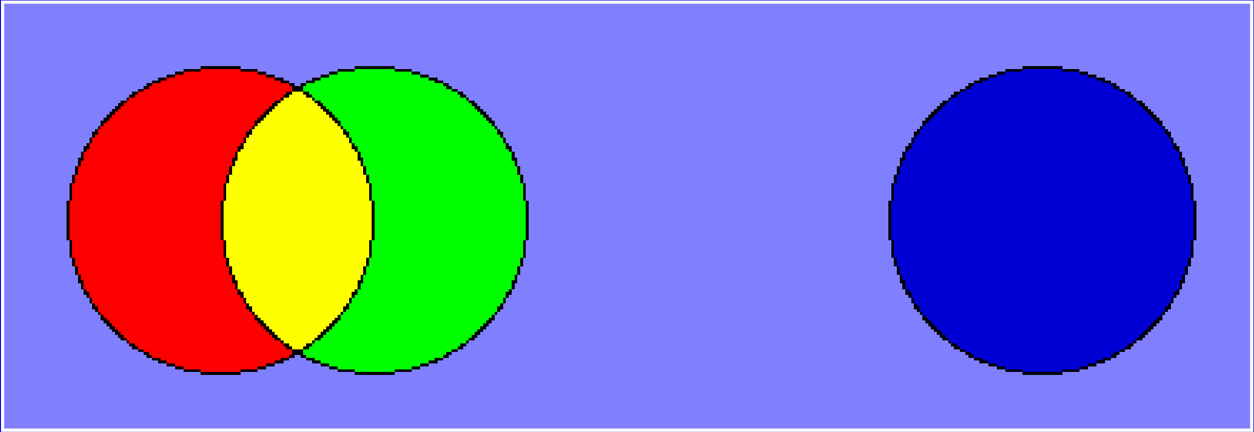
Primary Colors of Light

- Red, Green and Blue
  - Blue waves are approximately 500 millimicrons in length
  - Green waves are approximately 540 millimicrons in length
  - Red waves are approximately 640 millimicrons in length
- Called the additive system
  - Addition of electromagnetic waves results in stronger heat, sound or light.
- This system is used in computer monitors, cameras and color sca



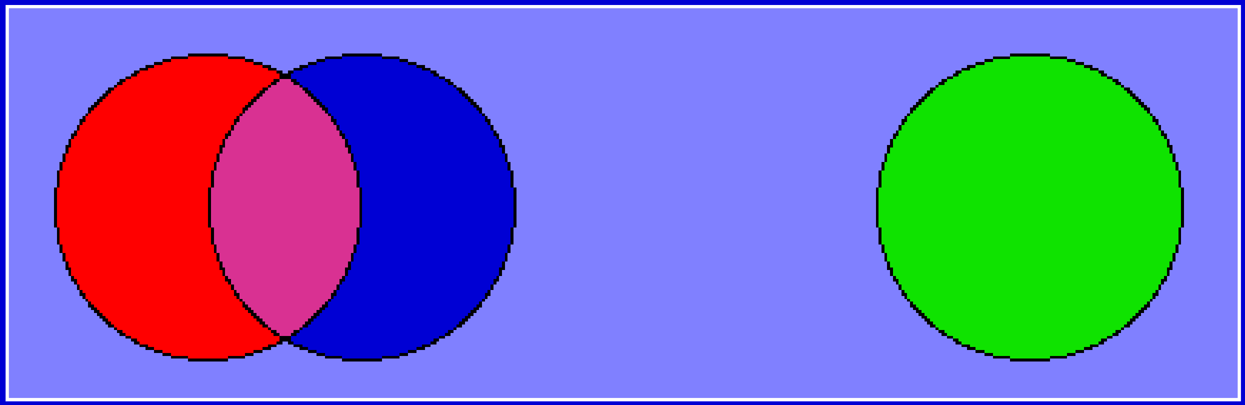
Combining Primary Colors of Light

- **Red + Green = Yellow**
  - **Yellow is a “secondary” color of light**



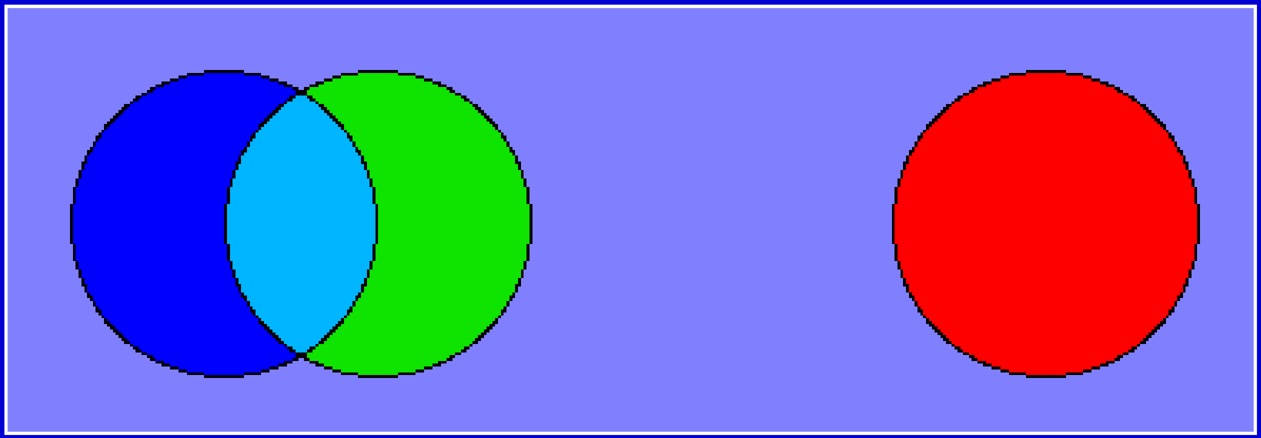
Combining Primary Colors of Light

- Red + Blue = Magenta
  - Magenta is a “secondary” color of light



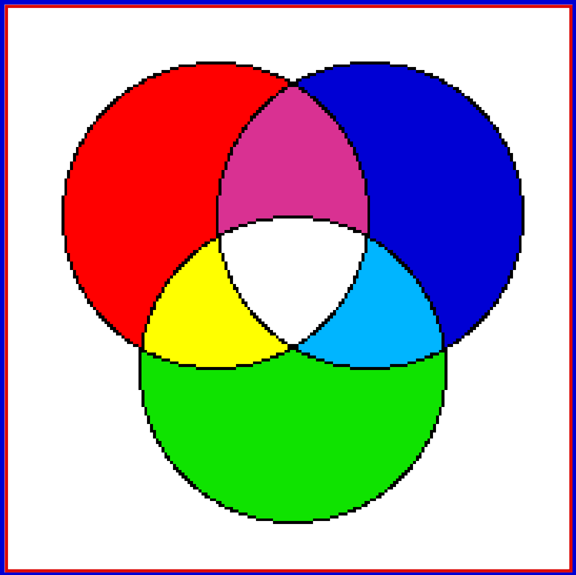
Combining Primary Colors of Light

- Blue + Green = Cyan
  - Cyan is a “secondary” color of light



Combining Primary Colors of Light

- Red + Green + Blue = White
- ONLY natural light is white
  - Only when the atmosphere allows it to be.

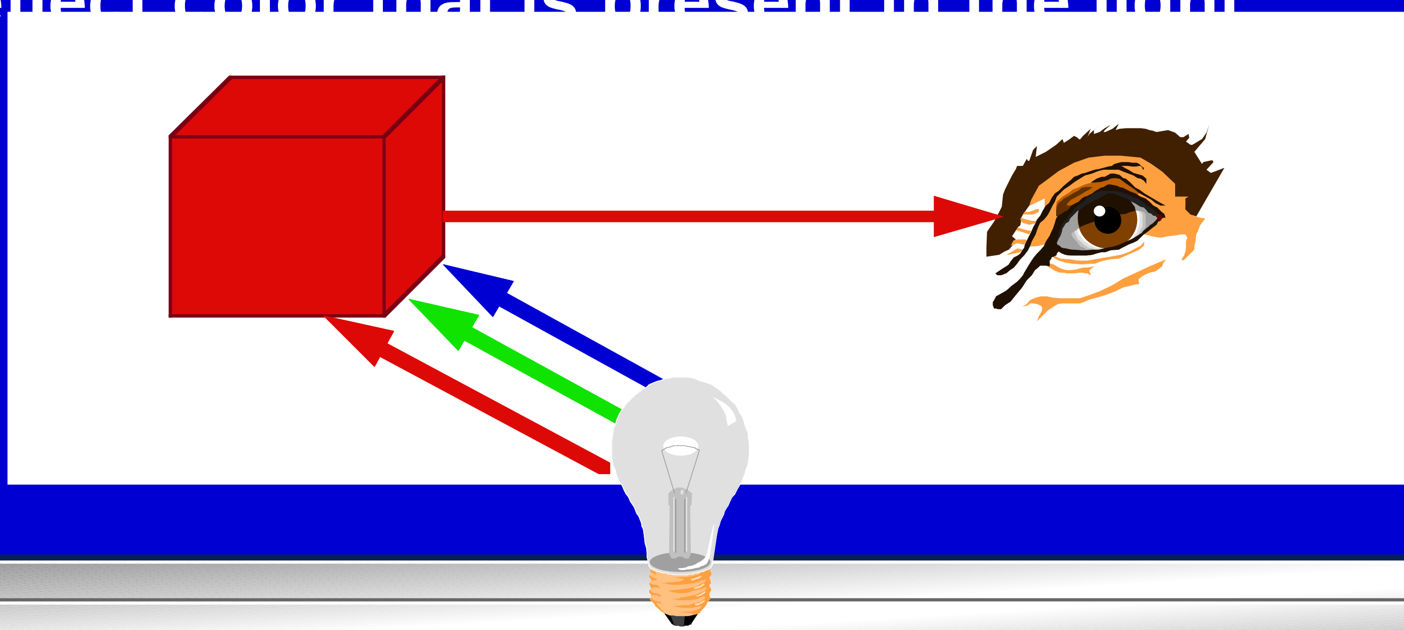


What about Black?

- Black is when no waves of light are combined.
- Black is the absence of all color.
- Does that mean that black objects aren’t really there?

How Objects are "Colored"

- Light strikes the object
  - Some waves of light are absorbed by the pigment in the object
  - Some waves of light are reflected by the object
- No object "has" color – it can only absorb or reflect color that is present in the light



Artificial Light Sources

Natural Sunlight	White + UV + IR	NA
Flourescent	Cyan	Room lighting
"White" flourescent	"White"	Color viewing
Black Light (flourescent)	UV	Dylux
Incandescent	Yellow	NA
Metal Halides	Blues	Plates, proofs
Quartz-Iodine	Yellow	Process camera
Pulsed-Xenon	"White"	Color cameras
Lasers	Vary	Laser printers
Colored Phosphors	Red, Green, Blue	CRTs
Liquid Crystals	Red, Green, Blue	LCD Displays

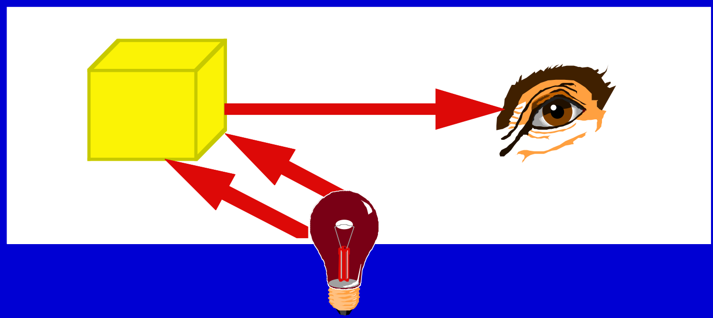
Measuring Color of Light Sources

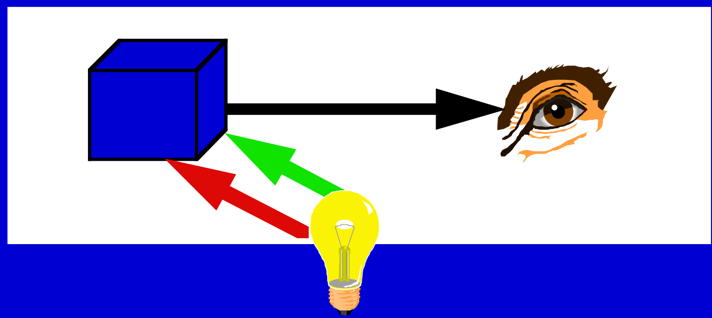
- **Degrees Kelvin (˚K)**

Natural Sunlight	5400˚ Kelvin
Regular Flourescent	7500˚ Kelvin
"White" Flourescent	5000˚ Kelvin
Incandescent	± 2500˚ Kelvin

Effect of Light Source on Object's "Color"

- An object can only reflect that which it receives.
- A picture of yellow object in red lighting appears red.
- A picture of blue object in yellow lighting appears black.





Effect of Light Source on Object's "Color"

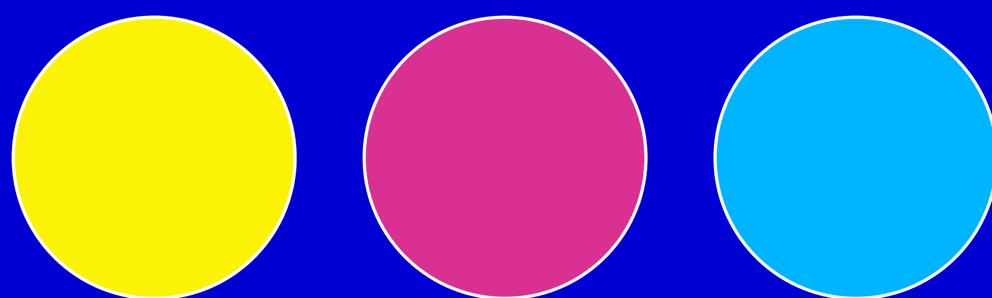
- Color Rendition Demonstrator
- Judgment of color needs to be done under controlled lighting
  - 5000˚K is commonly used in printing plants.
  - Some buyers want to view color under same circumstances as end-user.
  - No matter what, there must be standardization.
- Use of RHEM light indicator.

Printed (Subtractive) Color

- Printing processes do not use light waves to create color.
  - The additive primary colors of Red, Green, and Blue are not used.
- Printing processes use pigments to “subtract” color from a substrate.

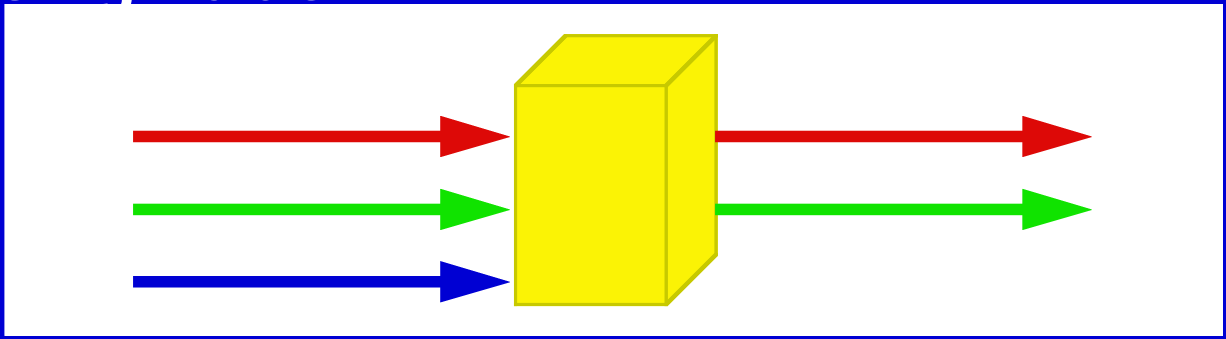
The Subtractive Colors

- The pigments are colors Yellow, Magenta, and Cyan.
- Yellow, Magenta, and Cyan are the Subtractive Primary Colors.
  - Note that the subtractive primary colors are the additive secondary colors.



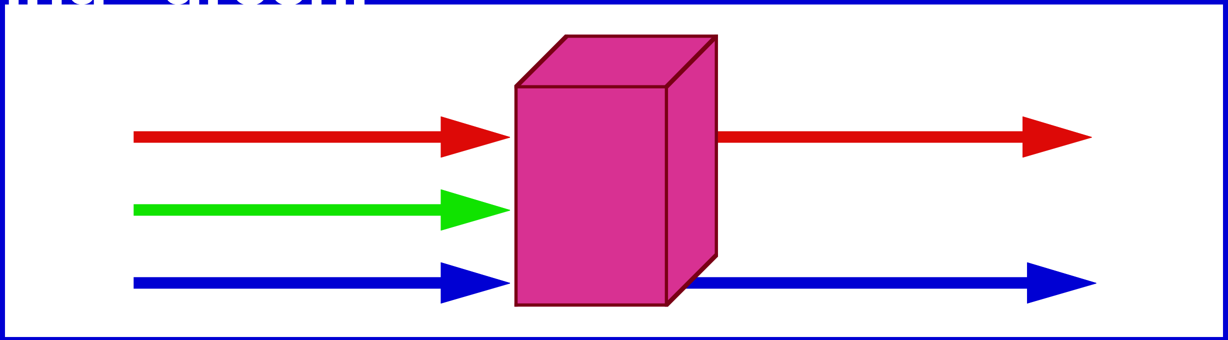
Subtraction of Colors by Pigments

- Yellow ink reflects red and green light waves.
  – These separate waves combine in the brain so that the viewer sees yellow.
- Yellow absorbs (subtracts) blue.
- Whenever you see “yellow” you are “not seeing” blue.



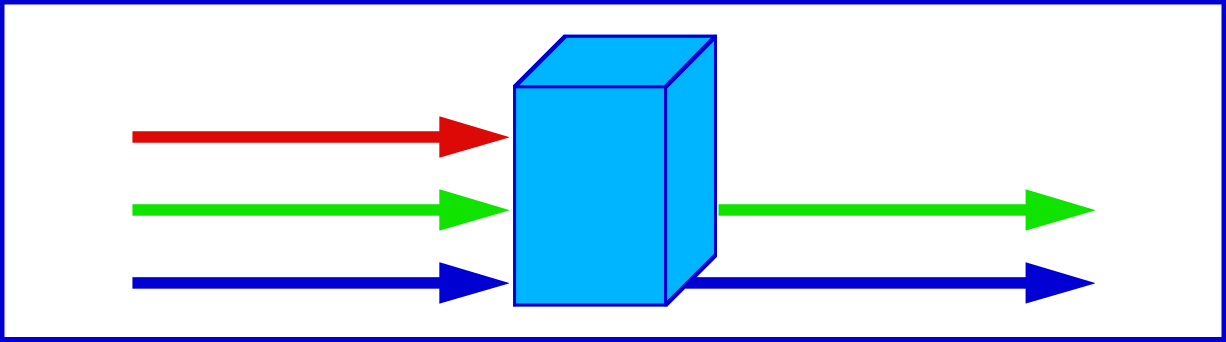
Subtraction of Colors by Pigments

- **Magenta ink reflects red and blue light waves.**
  - **These separate waves combine in the brain so that the viewer sees magenta.**
- **Magenta absorbs (subtracts) green.**
- **Whenever you see "magenta" you are "not seeing" green.**



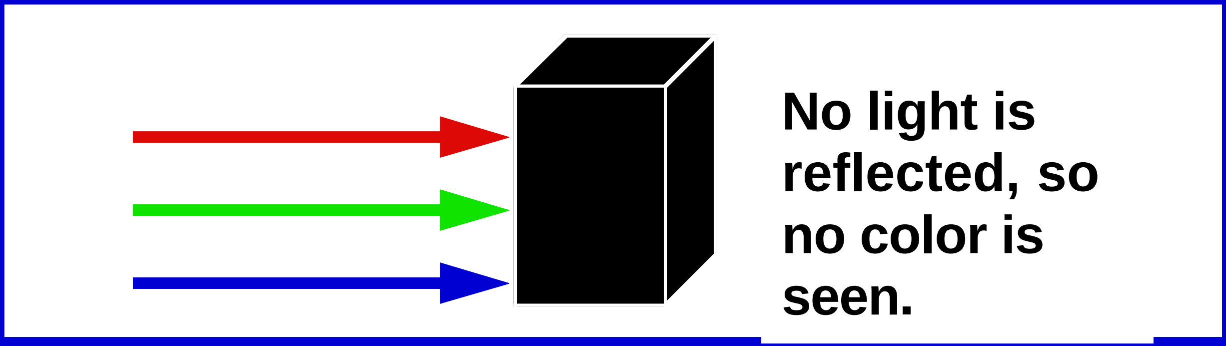
Subtraction of Colors by Pigments

- Cyan ink reflects blue and green light waves.
  - These separate waves combine in the brain so that the viewer sees cyan.
- Cyan absorbs (subtracts) red.
- Whenever you see “cyan” you are “not seeing” red.



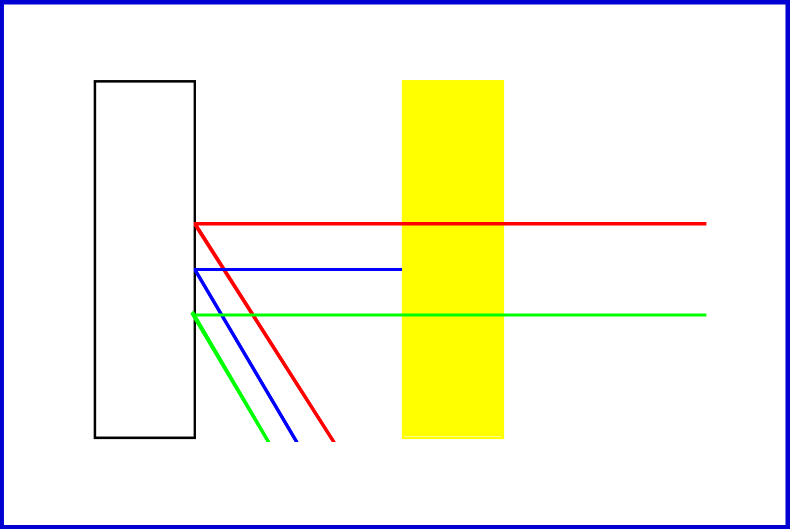
Subtraction of Colors by Pigments

- Black ink reflects no light waves.
- Black absorbs (subtracts) red, green and blue.
- Whenever you see “black” you are “not seeing” any color.



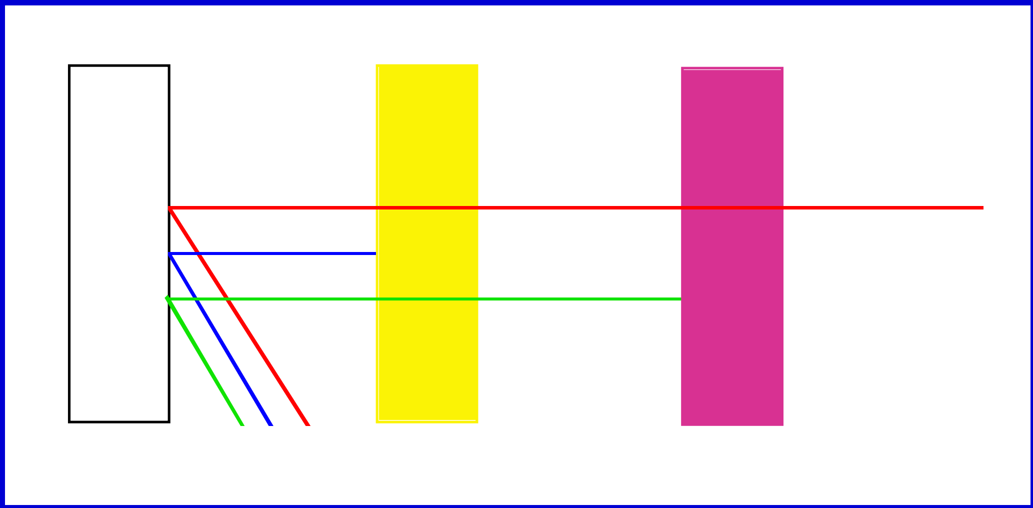
Combining Subtractive Colors

- Printing yellow ink on white paper results in yellow.
- White - blue = yellow.



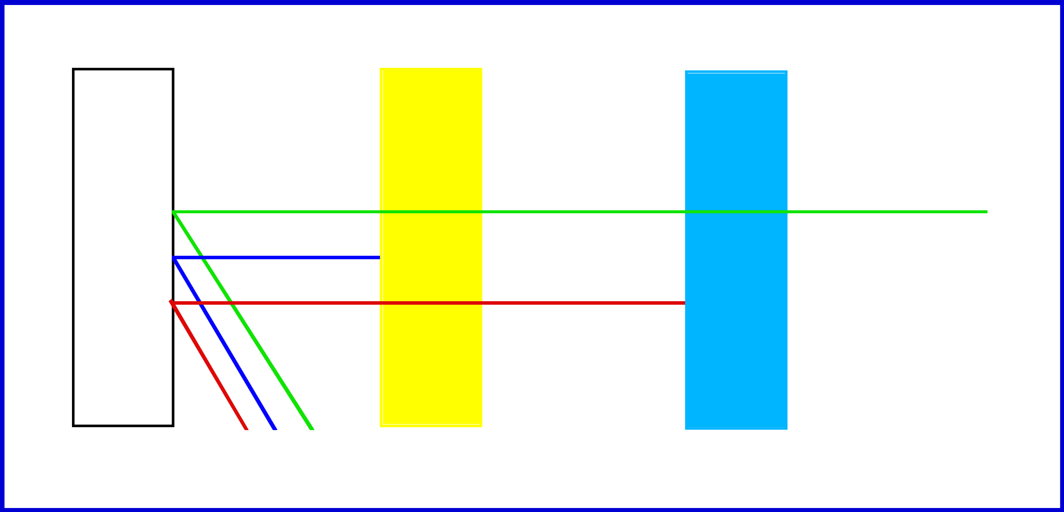
Combining Subtractive Colors

- Printing magenta over yellow results in red.
- White - blue - green = red.



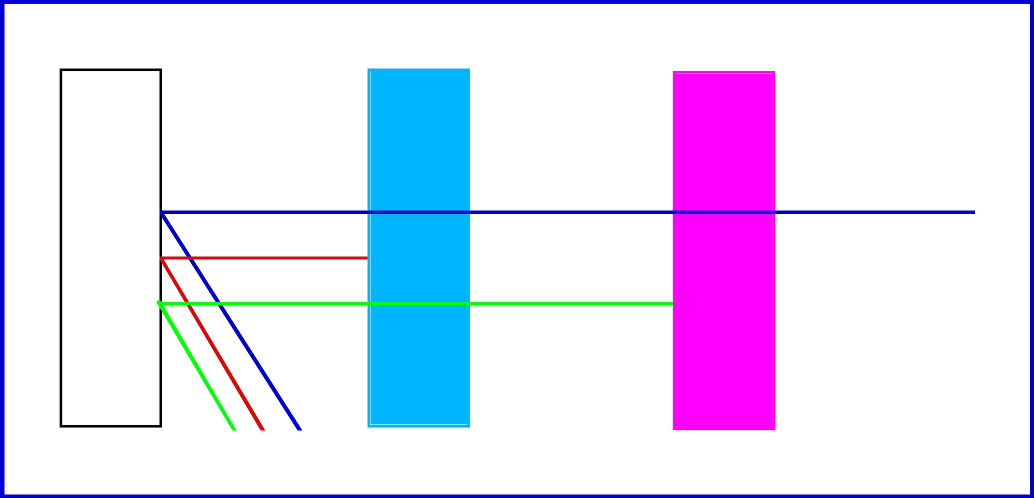
Combining Subtractive Colors

- Printing cyan over yellow results in green.
- White - blue - red = green.

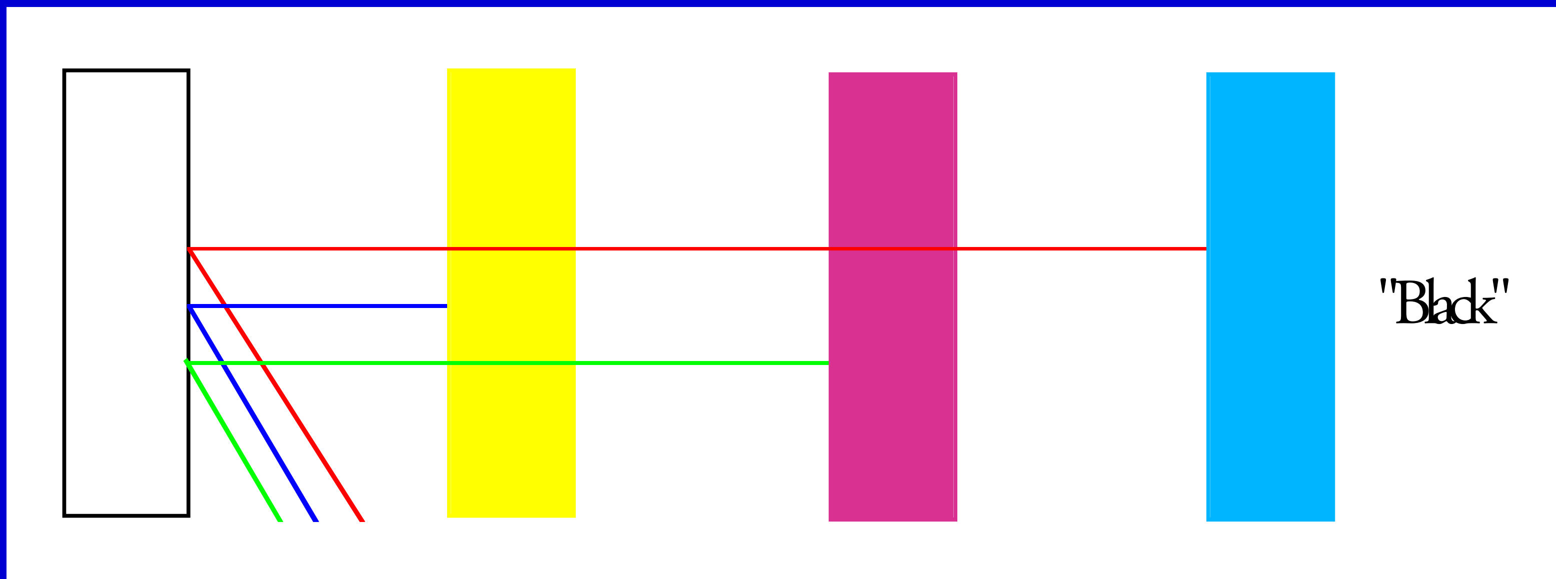


Combining Subtractive Colors

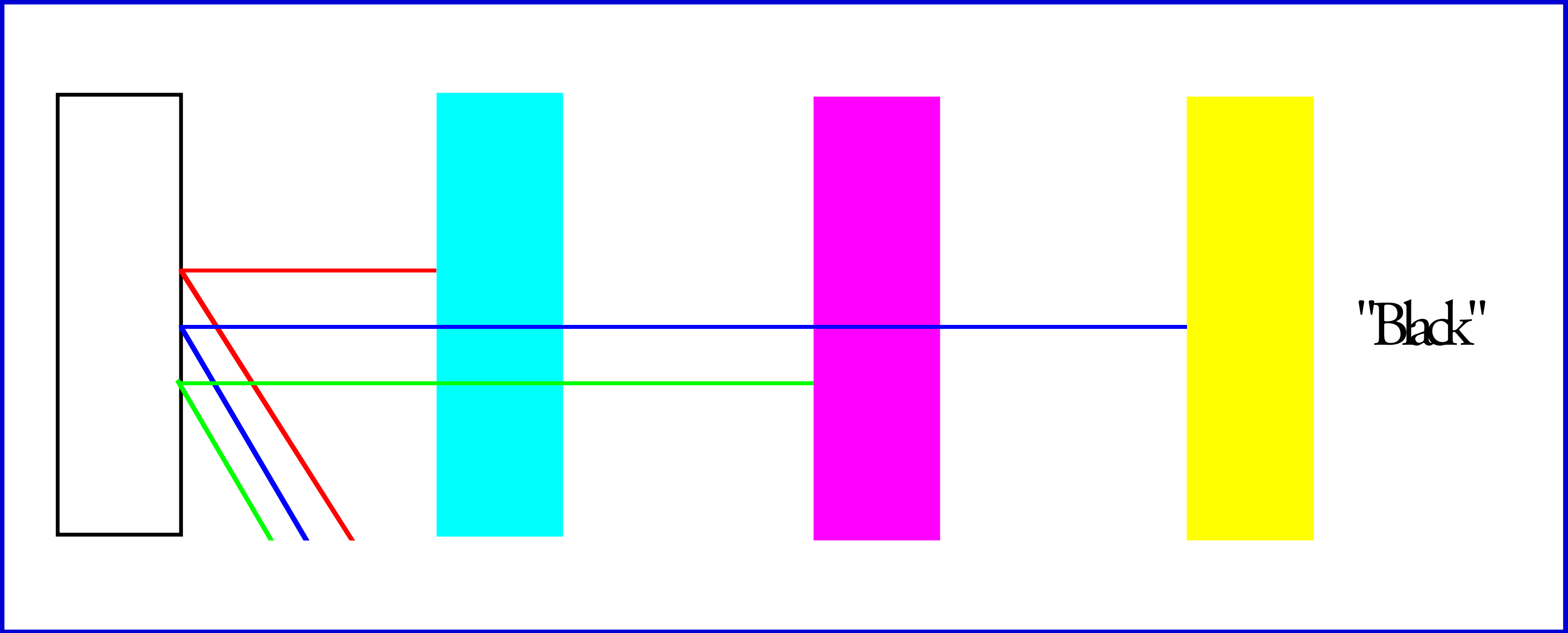
- Printing magenta over cyan results in blue.
- White - red - green = blue.



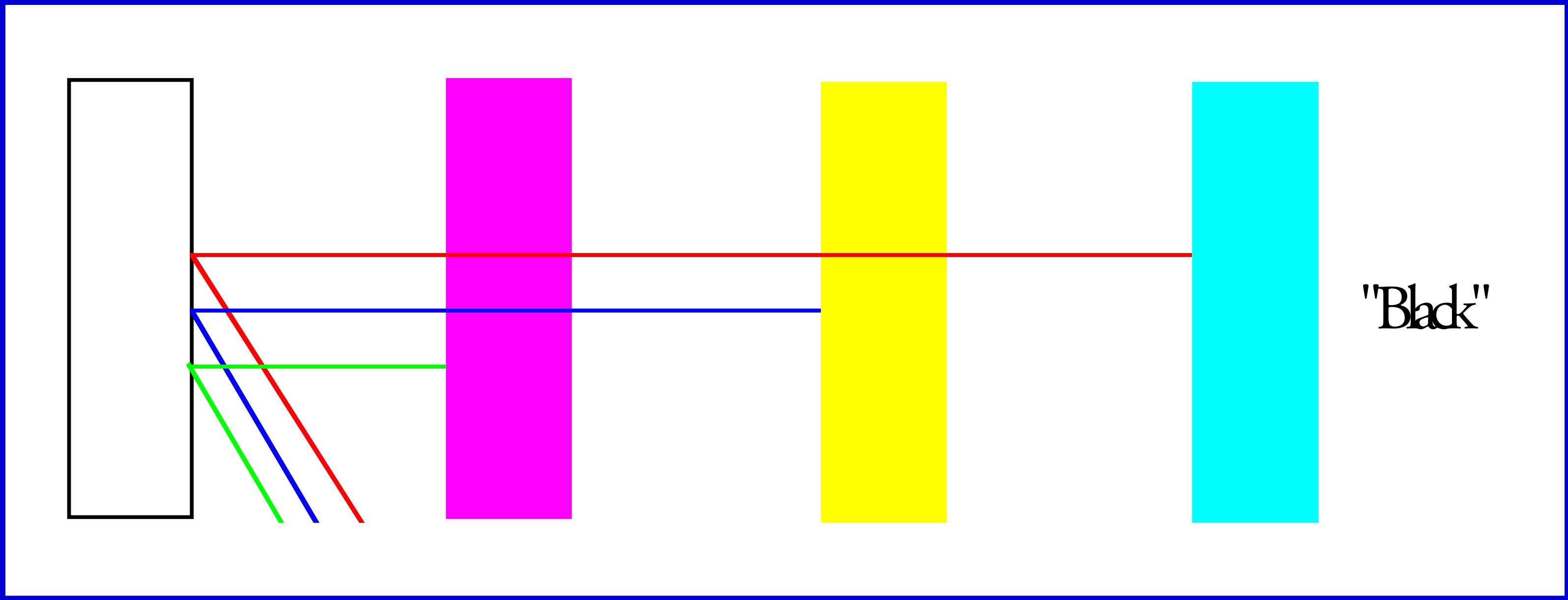
Printing Colors on a Press



Another Color Sequence

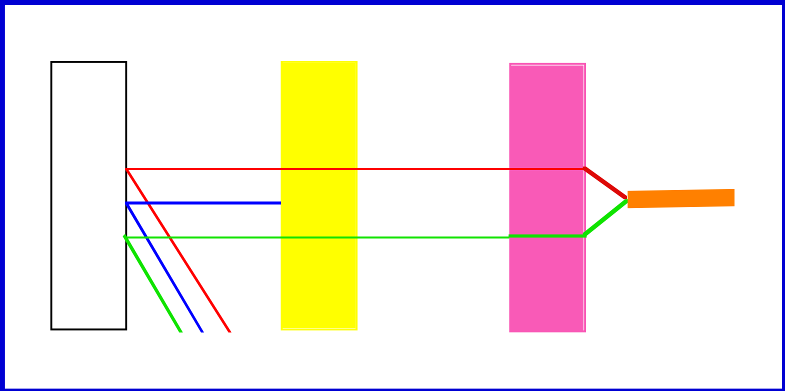


Another Color Sequence



Reproducing Other Colors

- Halftone dots
- For example, orange is red + yellow
- Using ink, red is composed of yellow + magenta.
- To make orange using halftone dots, you need twice as large yellow dots as magenta dots
  - 2Y + M



Proofing Color

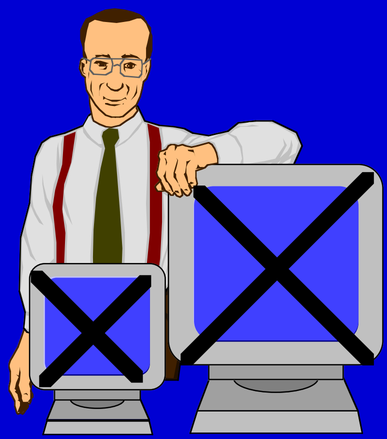
- Internal Control
  - to check for job's color, image accuracy, and registration
- External Control
  - for submittal to a client for approval
- The goal of proofing is to accurately represent what the press-sheet will look like.
  - The goal of a proof is NOT to look good.

Kinds of Proofs

- **Digital *preproof***
  - **Made from electronic files.**
  - **OK for some internal control**
  - **Does not accurately represent press sheet**
- **Contract proof**
  - **Made from the same films as plates**
  - **More accurate representation of press sheet**

Digital Preproofs

- Softproof
  - Computer monitor
    - » Uses additive rather than subtractive system.
    - » Monitors can be adjusted to change colors



Digital Preproofs

- Black & White or Color Xerographic Prints
  - Toner is not ink
  - Resolution won't match press
  - Paper may or may not match press sheet
- Color Ink Jet Proofs
  - Inks do not match printing standards
  - Resolution doesn't compare to press
  - Paper may or may not match press sheet

Digital Preproofs

- Thermal Wax
  - Wax does not look like ink
  - Resolution doesn't compare to press
  - Paper may or may not match press sheet
- Dye Sublimation
  - No halftoning effect – continuous-tone proof
  - Paper doesn't match press sheet

Contract Proofs

- Single-color
  - May be used for internal or external control
  - OK for single-color work
  - OK to check image position and accuracy
  - May be used to check color breaks
  - Not acceptable to check accuracy of color
- Types
  - Velox-type photographic prints
  - Diazo-type “bluelines”
  - Polymer-type (Dylux) “bluelines”
    - » can show color breaks

Contract Proofs

- Multiple-color
  - May be used for internal or external control
  - OK to check image position and accuracy
  - Shows color breaks
  - May not be able to reproduce non-process colors, such as PANTONE.
- Types
  - Overlay-type
  - Single-sheet type

Overlay Contract Proofs

- Require a separate plastic overlay for each color
- Advantages
  - Available from many manufacturers
  - Relatively inexpensive & quick
  - Can be placed on actual press sheet
  - Can be used as a “progressive” proof
- Disadvantages
  - Overlays add a sheen to the press sheet
  - Overlays add density to press sheet
  - Not all spot colors are available
  - May appear out-of-register
  - Colorants are NOT ink

Single-Sheet Contract Proofs

- Each separate image is built on one base sheet
- Advantages
  - Available from many manufacturers
  - May appear on actual press stock – looks like a press sheet
  - Colorants may match ink color standards
  - No overlays to appear out-of-register or add density
  - May build-in press characteristics
- Disadvantages
  - Costly
  - Spot colors may not be available
  - Cannot be used as a progressive proof
  - Colorants are NOT ink

Press Contract-Proofs

- The best proof
  - It not only resembles a press sheet, it is a press sheet
- Advantages
  - Same exact stock as press run
  - Same inks as press run
  - Builds-in press variables such as dot gain and effects of water-in-ink.
- Disadvantages
  - Press is probably not the same as actual press run
    - » May have different characteristics
  - Very costly & time-consuming

Proofing Problems to Consider

- Color model employed by proofing system
- Screening technique (or lack of)
- Do the colorants used by system match ink colors?
- Available colors
- Prediction of press characteristics
- Does the proof demonstrate dot-gain?
  - If not, the proof will look lighter than the press sheet.