

PRINTtips

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Color Us CMYK

Color influences us in many ways. It affects our thought process, guides our emotional response, and can even provoke a physical reaction. We use color-based phrases to describe emotion (*seeing red*, *feeling blue* or being *green with envy*) or attribute characteristics (cowardly yellow, black hearted, red blooded). Lack of color is associated with deprivation, while vibrant color connotes richness and vitality.

How color is produced

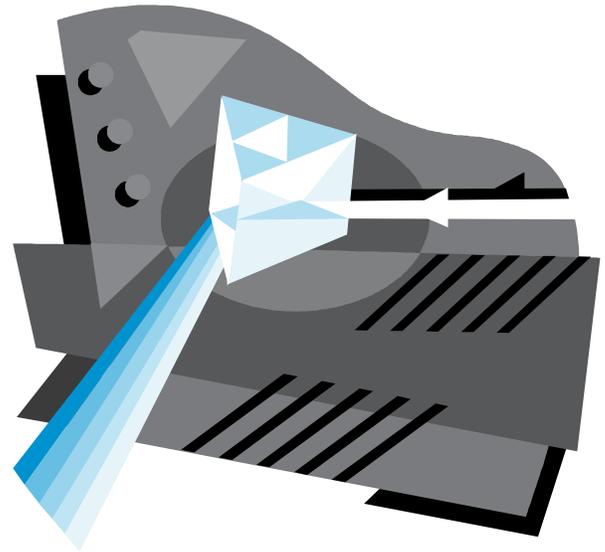
Color results from energy waves grouped in a *color spectrum*, and the *visible spectrum* is the part of the total spectrum that can be seen by the human eye. In *Opticks*, Sir Isaac Newton provided an early explanation of the visible spectrum and organized a *color wheel* or *color circle* to show the relationship between the colors in the visible spectrum (violet, blue, green, yellow, orange, red). A rainbow is a familiar representation of the visible spectrum.

Most color wheels have twelve main divisions: three primary colors, three secondary colors, and six intermediate or tertiary colors (formed by mixing a primary with a secondary).

- An *artist's color wheel* is based on the primary colors of blue, red and yellow; secondary colors of green, orange and violet; and tertiary colors of red-orange, red-violet, yellow-orange, yellow-green, blue-violet and blue-green.
- An *additive color wheel* is based on primary colors of red, green and blue (RGB) with secondary colors of cyan (blue), magenta and yellow. Taken together, all the colors of the additive color wheel produce white.
- A *subtractive color wheel* is based on primary colors of cyan, magenta and yellow with secondary colors of red, green and blue. Taken together, all the colors of the subtractive color wheel produce black.

Additive color: RGB

The basis for color produced by computer monitors is *additive*. Each pixel on the screen is composed of three *phosphors* (one each of red, green and blue) that emit light when struck by electron beams produced at the rear of the screen. If no



electrons strike the phosphors, they emit no light and appear black. If all three phosphors are struck simultaneously with the same intensity, they produce white; less intensity produces gray.

The additive primary colors of red, green and blue are produced by striking the respective color phosphors singly. Secondary colors are produced by striking two phosphors with equal intensity (green + blue = cyan; red + blue = magenta; green + red = yellow). All other colors are produced by striking two or three phosphors with different intensities. Because the phosphors in each pixel are so small and close together, we do not see the phosphors individually but instead see the colors formed by the mixture of light.

Here is a way to remember additive color: it begins with the absence of light (black) and uses red, blue and green transmitted light singly or in two-light combinations of the same or different intensity to produce all other colors. All three colors used together in the same intensity produce white.

Subtractive color: CMYK

Unlike RGB color which is produced by transmitted light, printed color is produced by mixing transparent pigments on

a piece of paper. The resulting color results from the wavelengths of the visible light spectrum being absorbed (*i.e.*, subtracted) then reflected back to the viewer. This is called *subtractive color*.

To demonstrate subtractive color, consider a piece of paper as the reflective substrate. It has no light energy of its own. Rather, white light strikes the paper; the ink pigments on the paper absorb (subtract) portions of the white light; then reflect back the remaining part of the white light to the viewer (which could be the human eye, film in a camera, or a light-sensing instrument).

If the paper reflects all the white light back to the viewer, the paper appears white. If the paper absorbs (subtracts) all the light illuminating it, no light is reflected back to the view and the paper appears black.

Because printing inks are transparent, they allow light both to pass through to and reflect off the paper. Thus it is the paper that reflects any unabsorbed light back to the viewer. The primary process printing inks are cyan, magenta and yellow (CMY). Cyan absorbs red light and reflects green and blue light, which appears as cyan. Magenta absorbs green light and reflects red and blue light, appearing magenta. Yellow absorbs blue light, reflects red and green light to appear yellow.

The secondary colors are produced by overprinting primary colors. Overprinting magenta and yellow absorbs green and blue; reflects red; and so appears red. Overprinting cyan and yellow absorbs red and blue and reflects green, to appear green. Overprinting cyan and magenta absorbs red and green and reflects blue, to appear as blue.

In theory, overprinting cyan, magenta and yellow absorbs red, green and blue (*i.e.*, the full visible spectrum of white

light) and reflects back no color, thus appearing black. Actually, the overprint is a muddy brown, so black (K) is added as a fourth process printing ink. The designation *K* is to avoid confusion with *B* for *blue*.

Here is a way to remember subtractive color: it uses pigments of cyan, magenta and yellow to absorb (subtract) the portions of white light that are illuminating the reflective substrate or object, which then reflects back the remaining portion of white light back to the viewer. Equal amounts of cyan, magenta and yellow produce black (appearing as a muddy brown).

Preparing to use subtractive color

To prepare an image for reproduction using subtractive color, the image must be converted to a pattern of small dots, one dot for each primary color (CMY) + black (K). Equal amounts of two overlapping primary colors produce the secondary colors of red, green and blue.

All other colors are produced by using a tint (*i.e.*, a dot pattern) of the primary colors which changes the percentage of each primary color in the overprint. In addition, the angle of each dot is rotated at a specific degree to prevent an undesirable pattern called *moiré*. When printed at the proper angles, the dots combine to form a pattern of dots in a ring called a *rosette*.

Process ink colors

Process inks are not completely transparent, nor are they completely pure. This means that each primary color will reflect a slight amount of the primary opposite, and absorb a slight amount of the rest of the spectrum. This characteristic means that both the source of light and the paper on which the inks are printed affects the appearance of the color.

Remember that in subtractive color, the light passes through the ink to the paper, with part of the white color

spectrum absorbed in the process. Then the remaining light is reflected off the paper and back through the ink to your eye. Paper with a rough finish absorbs more light than paper with a smooth finish, affecting how the color appears to your eye. Likewise, the color of the paper itself can affect the amount of absorbed light and therefore the perceived ink color. In general, the darker the paper, the more its color will influence the appearance of the printed image.

RGB to CMYK

We hope this explanation of additive and subtractive color will help you understand why we ask you to prepare your full color documents using CMYK color values rather than RGB, and why we may not always be able to print exactly what you see on your computer monitor. Not only is your computer monitor able to produce more colors than our printing inks, there are some colors (like certain shades of blue) that don't reproduce identically when created with phosphors versus transparent ink. Please call us if you would like to discuss this further.

a vocabulary of the graphic arts

Additive primary colors: the primary colors of light – red, green and blue – from which all other colors can be made.

Black: the absence of light; the color that is produced when an object absorbs all light.

Brightness: the degree to which a color sample appears to reflect light.

Color: the human perceptual response to different wavelengths of light impinging on the photoreceptors in the retina.

Color space: a three-dimensional representation of the colors that can be produced by a color model such as RGB or CMYK.

Colorants: materials used to produce color, such as dyes, inks, pigments, toners, or phosphors.

Cyan: a subtractive primary color. Cyan colorants absorb all red light, reflects green and blue to appear blue.

Device-dependent: a color space defined in terms of physical colorants, such as a monitor's RGB or a printing press' CMYK. The color produced by device-dependent values depends on the physical properties and colorants of the device.

Four-color process printing: the process of reproducing a full-color image by overprinting screened color separations for each of the three process colors (cyan, magenta, yellow) + black ink. Also called *full color printing*.

The Pantone Matching System is used by document creators and printers to select, specify, match and control ink colors. The Pantone Matching System formula guide is a book of printing ink formulas and samples printed on coated, uncoated and matte coated stock in a fan format.

Whereas the primary process printing colors of cyan, magenta and yellow are combined via overprinting to produce a specific color, a PMS or *spot color* ink is one single hue. In addition, the inks used for spot color are opaque rather than translucent and so do not allow white light to pass through nor absorb any part of the white light spectrum.

Hue: the attribute of a color that describes its dominant wavelength (such as red, yellow, green, blue).

Magenta: a subtractive primary color. Magenta absorbs all green light, reflects red and blue to appear magenta.

Primary colors: the colors from which all other colors can be made. The primary colors of light are red, green, and blue (additive primaries). The primary colors of pigments are cyan, magenta, and yellow (subtractive primaries).

Saturation (also known as chroma): the property of a color that makes it appear strongly colored. Black, white, and gray lack saturation; pastels have low saturation.

Spot color: designates a single hue printing ink, usually based on the Pantone Matching System.

Subtractive primary colors: the primary colors of pigments – cyan, magenta, and yellow – from which all other subtractive colors can be made.

Yellow: a subtractive primary color. Yellow absorbs all blue light, reflects red and green to appear yellow.

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For its PMS colors, Pantone provides a formula of what percentages of cyan, magenta, yellow and black ink to use to simulate the single hue of a PMS color. While in general these translations work well, there are times when the CMYK equivalent of a PMS color will not be a perfect match.

When it is important in your full color document for the PMS color to be true, it may be necessary to print in the four process colors, and then use the actual PMS color as a fifth ink. To discuss the implications in cost and time, please call us.

TRICKS & tips

When you are experimenting with colored paper for your printing project, there are several ways you can get a sense of how the stock color will affect the color images to be printed:

- *Ink drawdown.* A thin film of ink applied by an ink knife or spatula that demonstrates the interaction of the ink and paper colors. A drawdown can be done for a Pantone color but will not show how full color images will appear.
- *Request that samples of your stock be added to the end of another press run.* This can be used to check full color images and also provides an alternative to an ink drawdown.
- *Digital proof.* Another option is to use a digital printer to put the image on the stock. Do remember that digital images are produced by toner (a dry ink) and so can only approximate the look of offset. We do not recommend digital proofs for color-critical projects.
- *Press proof.* For very exacting jobs, we can put the job on press for a press proof. In this case we would set up the job, print a few test sheets, but complete the job at a later time.

Each method has an associated cost in both time and money. We will be happy to provide the information so you can make an informed decision.

Q. Can I print in white ink?

A. Not really. Often what appears as white ink is actually a *reverse* – a solid block of ink with the image appearing within the block. What looks like white ink is actually the paper showing through the block of ink. Here is an example of a reverse:



Reverse

There is an opaque white ink, but it is normally used as an undercoat to block the effect of the paper color rather than as an ink color.

One alternative is to use foil stamping to create the appearance of white ink. Foil is available in a wide variety of colors and finishes; a white matte foil would simulate white ink. This technique would be effective when using black paper (such as on a business card, presentation folder or handbook cover).

questions and answers