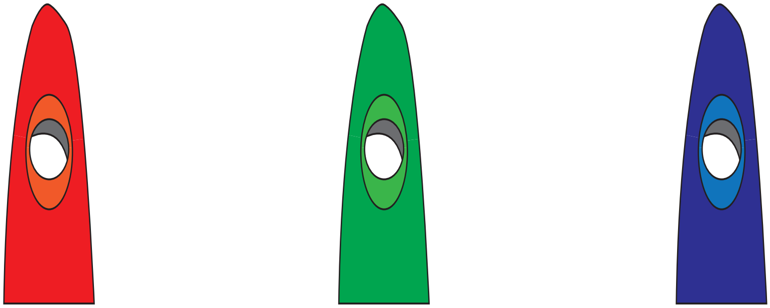
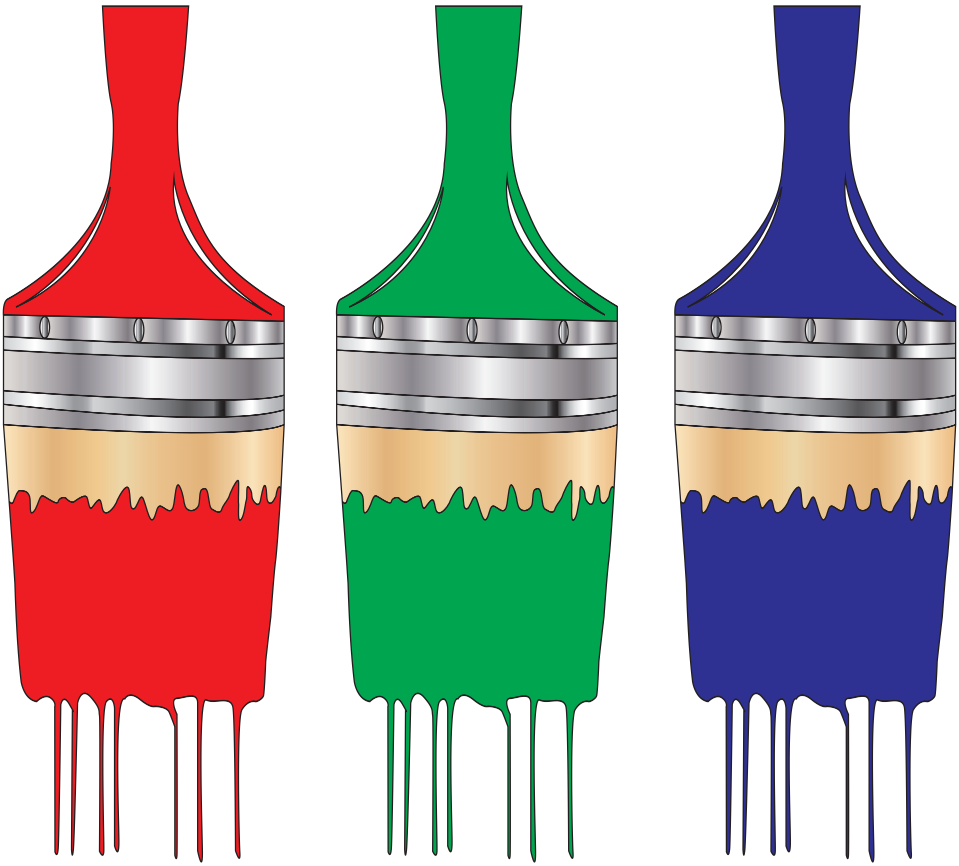


Colour Theory Basics

Your guide to understanding colour in our industry



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RGB

Additive Colours

White light is made up of many different colours that use different wavelengths to band together to form the colours that we see every day. When they all equal out we get white light. Red, green and blue are the primary colours of this white light and by using various mixtures of these coloured wavelengths you get the entire spectrum of visible light.

What we see and what we are able to see when we view digital media is additive colour. Because red, green and blue are the predominate primary components of this spectrum we call additive colour RGB colour. This huge spectrum of possible colours is why digital media has such an impact.

When you add two of these primary colours together you get a brighter colour than either of the two primary colours

Red + Green = Yellow
Red + Blue = Magenta
Blue + Green = Cyan

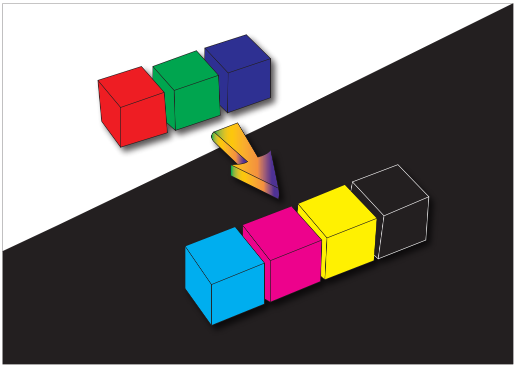
By using unequal amounts of red, green and blue light you get new colours and when you subtract all three of them you get black.

Subtractive Colours

Where additive colour uses light to produce colour, subtractive colour removes light in order to produce colour on a printed surface material so the process works in reverse to RGB colour and starts with Cyan, Magenta and Yellow (which then form Red, Green and Blue and ultimately black) and working back through to black by partially or completely masking colours on a lighter coloured background (predominately white). Using ink minimises the light that would usually be reflected from the light background, subtracting the reflection which gives the model its name.

The black that is formed by this process is not a true black it tends to be added by printers into the equation which also minimises having to use as much coloured ink in order to create black. Because these colours are used the process is called the CMYK colour range with “K” representing black which describes both the colour model and the printing process itself. Black is represented by the letter “K” because in printing (although it can vary from print house and press runs), ink is usually applied in order of the abbreviation and the “K” stands for the first letter of the black key plate.

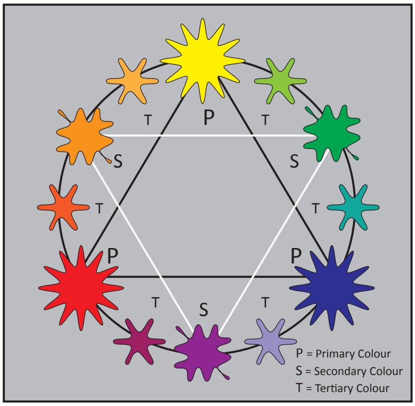
In order to produce a larger range of colours than the above seven colours (cyan, magenta, yellow, red, green, blue and black) printers use a process known as halftoning (also called screening) where less saturation of ink is used of the primary colours which results in the human eye seeing the results as a different colour.



RGB and CMYK The relationship

We have already learned that RGB is a result of coloured light combinations whereby equal amounts of red, green and blue light create white light and the removal of red, green and blue light create black and CMYK is a reversal of the process whereby the printer starts with cyan, magenta and yellow and works back through the colour range by adding these primary colours to a light (usually white) background and forming red, green and blue as a result and by using halftones or screening many other colours can be created but how does this relate to printing?

Well RGB colour models are restricted to wherever light can be used in the process. Digital media make full use of RGB colours to their fullest. A much wider spectrum of colours is possible with RGB colour than CMYK colour because RGB is what we see every day and CMYK is an attempt to reproduce those colours onto various materials, also known as substrate.



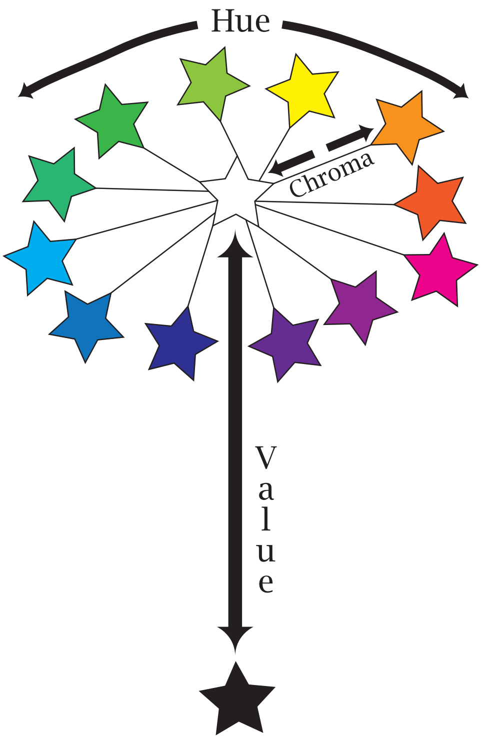
In order to reproduce the colours that we see we need cyan, magenta and yellow inks, dyes or paints that we can then use with various printing presses or printers to transfer this ink to the substrate we want to see them on. We have already learned that RGB colour allows us to see a lot more than CMYK so there are a much more limited range of colour possibilities when using CMYK but using some other colour models i.e. Pantone spot colour ranges (that we will learn about later in this booklet so keep reading...) printers are able to get closer to what their customers desired results. The trick is in being able to find a way to reproduce the colours that someone sees onto a printed surface and to be able to do it consistently.

Hue, Value and Chroma

Every colour has three sides to its unique identity. We call these areas hue, value (or tone) and chroma (or saturation). All three need to be considered when trying to mix a specific colour.

Hue represents the actual colour of a pigment or ink. Judging which hue you want to use is the very first part of the equation when colour mixing as it tells you which colours you need to be identifying for the task.

Value (tone) is a measure of how light or dark a colour is without using hue as part of that equation. Think of this as a grayscale measurement where you can see everything but there is a distinct absence of any obvious colour and we are going on how much light (or a lack of light) we are able to see.



Chroma (saturation) is a measure of how pure/intense the colour is where at the high end of the chroma scale a colour is pure and bright and at the other end (where it has been diluted) it is a shade of grey.

Getting the mix right is important in more ways than one. First up you get the colour you are after when you consider all three carefully, next you waste less ink and lastly you get a better result.

When printing on substrate you have another hurdle to jump. Colours look different when printed onto different substrate. Some substrate absorb colour, some reflect. A shiny surface is going to give a colour a different look to a matt surface.

Colour Matching and Colour Systems

Reproducing colour accurately has been a difficult process. What we see isn't always what we get when it comes to the colours that we want to replicate but back in 1993, eight industry vendors got together to create an open, vendor-neutral colour management system that could be used to span all operating systems and software packages and they called themselves the International Colour Consortium (ICC). Their specifications allow for matching colour when transferred between applications and operating systems from the point of creation to the final output regardless of whether display (RGB) or print (CMYK etc.) was the objective* using "working spaces" (the colour spaces where colour is going to be manipulated)

The ICC defines the format precisely but doesn't define the various algorithms or processing details which means that there is space for variation between different applications and systems to form their own identity whilst working within ICC parameters.

- Various instruments can be used to measure device colours ranging from colorimeters through to spectrophotometers which take a measure of the colour data and convert it into a gamut* profile which results in the ideal colour description or the colours "profile".
- Calibration of all of the devices used in the process from creation to final result is ideal to ensure that all of the devices in the process are able to handle the colour representation required consistently and accurately. Using a common standard colour space like sRGB may mean that no colour translations are needed throughout the process
- Working spaces i.e. sRGB, Adobe RGB etc. that allow for colour editing while still remaining true to ICC colour matching requirements
- Colour transformation/conversion is the process where colour data is transferred from one colour space to another and is achieved by a colour matching module which adjusts the data received in order that the colour remains consistent. The problem is how to transfer a colour from one device to another device that may not be able to reproduce that colour without changing the result. The performance depends a lot on the capabilities of each colour matching method and that's why it is important to calibrate all machinery in the process to minimise the tweaking that has to be done further down the line
- Different operating systems handle the information differently, but all of them work within the framework of the ICC recommendations to keep colours consistent despite the different platforms

As you can see, prior to the ICC forming this standardisation of colour representation, Colour matching would have been a bit like Chinese whispers with the end result bearing very little resemblance to the initial colour. We can now be content in the knowledge that what we see, we can usually get.

* Note put this as a footnote ICC.1:2010-12 Standard is identical to ISO 15076-1:2010
* "gamut" - A subset of colours within a colour space or used by an output device at any given time

Colour Management

All of the processes of colour management can be separated into four main stages

1. Image input - this is where the information about an image is digitally recorded by a device (scanner, digital camera etc.) in the form of metadata which is then transferred to a computer publishing system. The image can be processed further here if required

2. Colour correction - Colour metadata can be manipulated within a colour space Lab as required using various applications standardised for the purpose

3. Conversion to output - metadata is preserved throughout the transferal process from device to device and is converted from RGB to CMYK mode ready for printing

4. Soft proof - in order to make sure that the colours are printing out accurately it is wise to create a soft proof or physical example of the print run.

To get the very best results all technology used in the process should be calibrated and standardised.