

Colour is a complex subject, one that numerous publications have grappled with.

What is colour?
How can we define it?

Colour is a physical phenomenon, a science that is taught in colleges and universities, and yet it is also associated with sensations that we can feel, interpret and express according to our taste or temperament. Colours can represent our moods and feelings; they can even refer to a musical genre: think of the blues.

Red is associated with heat, and blue with cold.

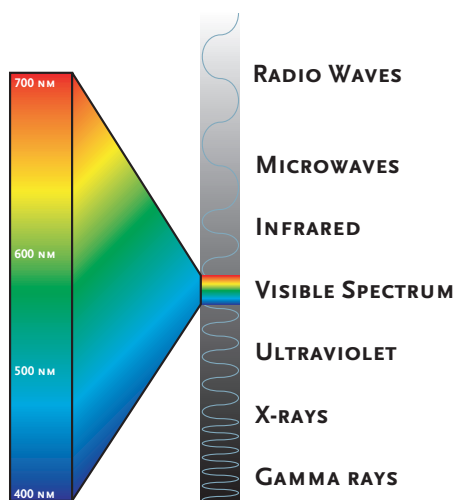
Yellow can inspire joy, green can be comforting, and black can denote sadness. Or, depending on the individual, such colours can take on different attributes. In short, we cannot discuss everything there is to know about colour in these few pages.

Therefore we will touch on just a few aspects of this subject, but we hope that the information contained here will be, as it were, enlightening.

Enjoy!

The basic principles of COLOUR

THE ELECTROMAGNETIC SPECTRUM



The nanometre (nm) is a unit of measure used for extremely small distances. One nanometre equals a billionth of a metre, or 0.000000001 m.

LIGHT

Visible light is made up of electromagnetic waves. Each family of light rays is characterized by a range of frequencies. The human eye can perceive only a minute portion of the wavelengths that constitute rays of light. The electromagnetic spectrum is divided according to the wavelengths of the various types of radiation: X-rays are waves of microscopic dimensions; infrared rays are made up of waves that are approximately the size of a pinhead; and at the other end of the spectrum are radio waves, which have a much longer frequency. Because these wavelengths are of greatly differing dimensions, different units of measure are required to calculate them. To measure the visible portion of the spectrum, we use nanometres (nm). The first table illustrates electromagnetic radiation, from the weakest rays to the strongest.

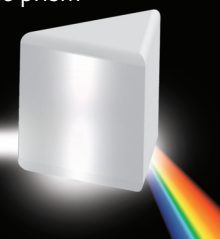
THE EYE

When light radiation reaches the eye, an image is formed by the lens and is then projected onto the retina at the back of the eye. The retina is lined with light-sensitive nerve endings that act as photoreceptors. The eye has two types of receptor cells: rods and cones. The rods function according to brightness, or “luminosity”: we perceive things monochromatically (i.e. in shades of grey) in weak light. Cones, on the other hand, are sensitive to different wavelengths, and allow us to perceive colour when light is sufficient.

The brain reconstitutes the information transmitted by the photoreceptors. Because our perception of colour is based on an interpretation made by the brain, we can only evaluate colour subjectively. In other words, we cannot be certain that a given colour will be perceived the same way from one person to the next. Several factors can influence our perception, notably our tastes and our moods. As with odours, certain colours may strike us as being agreeable while others do not. Our age, physical condition and frame of mind are other elements that can influence our perception of colours.

Isaac Newton (1642-1727) established that white light is composed of the combination of all the waves of the visible spectrum.

To demonstrate his theory, he directed a beam of light onto a glass prism. The refraction of the light as it passes through the prism causes the colours to disperse into a rainbow-coloured spectrum.



Properties of Light

How can we define the specific quality of a light source? A precise method for describing and quantifying light exists: this is the Kelvin temperature scale.

Using this system we can assign objective numerical values to describe light. The principle can be demonstrated as follows: let's heat, in a progressive manner, a piece of metal, which we shall call a black body. As the temperature rises, the black body will begin to emit a deep red light, which will gradually become a bright red light, and finally the black body will become "white hot."

The lower the light temperature, the closer it is to the colour red; the higher the light temperature, the more it appears blue. We find here a contradiction with regard to the qualities that we normally associate with these colours, since we usually consider red to be hot and blue to be cold.

Here are a few examples of temperature variation: the sun measures 5000 degrees Kelvin at midday, and 4000 degrees Kelvin in the morning and in the evening. The value for a fluorescent lamp is 6500 degrees Kelvin; a computer screen also has a value of 6500 K.

LIGHTING

The appearance of colours depends on ambient lighting, which affects our perception. You have probably experienced this phenomenon. For instance, the shirt you buy in a store that is lit with fluorescent light invariably looks different once you look at it at home under incandescent light. The greenish light emitted by the store's fluorescent tubes and the reddish light found at home produce two different effects when reflected by the shirt, thus altering our perception of its colour.

A red apple appears red when seen under white light because the apple has absorbed the colours that are included in the blue and green wavelengths of the white light, and has reflected only its red wavelengths. If the same apple is viewed under a light source that does not contain red wavelengths, the apple will appear grey, since it will have absorbed all the wavelengths that are illuminating it.

Precise visual perception is essential for ensuring the quality and success of a print project. Even the trained eye of someone who is experienced at colour proofing can be fooled when lighting conditions affecting the appearance of colours do not meet industry norms. The American National Standards Institute (ANSI) and the International Organization for Standardization (ISO) have set the standard for light sources used for the purposes of colour evaluation at 5000 degrees Kelvin. To comply with this standard, some manufacturers of fluorescent tubes place a "D50" designation on their products. This standard mimics natural daylight by offering balanced lighting. When examining colour proofs, it is advisable to use a viewing booth that meets industry norms.

COLOUR PROOFS

We produce colour proofs so that we can predict the appearance of a job once it has been

The Three Attributes of Colour

Hue

Hue is the attribute that allows us to define colours as yellow, green, red, blue, etc. Differences in hue are due to variations in the wavelengths of the light reaching the eye.

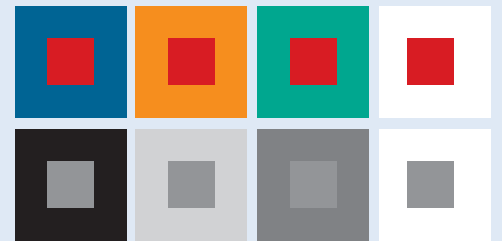
Saturation

Saturation is an expression of the intensity of a colour. The lower the saturation, the duller (or greyer) the colour appears. When saturation is zero, colour is non-existent.

Brightness

Brightness (or luminosity) refers to the relative lightness or darkness of a colour. It is determined by the degree of reflectivity of the surface receiving the light. The lower the brightness, the darker the colour appears.

Adjacent Colours Affect Perception



A colour may appear lighter or darker, or it may appear altogether different, depending on the colours that surround it. When checking a colour proof we pay particular attention to the details we want to examine but we are unable to disregard the other elements that appear in our field of vision. The samples presented here illustrate this phenomenon. The colours in the centre are the same, and we can demonstrate this by taking a colour value reading. But the surrounding colours distort our perceptions. By masking out these surrounding areas we can gain a truer perception of the actual colour. Luckily, most of the proofs we examine do not feature such pronounced contrasts, but to avoid problems it is nonetheless important to be aware of the influence that such contrasts have on our perception of colours.



1930 K



2865 K
100-watt
Tungsten bulb



5000 K
Midday



6500 K
Cloudy skies



6500 K
Fluorescent tube

Colour Range

In nature we find an enormous range of colours. When we try to reproduce these colours we are immediately confronted by the limitations inherent in the various methods and forms of reproduction. No system of reproduction can capture all the colours present in nature. A greater range of colours can be reproduced on photographic paper than on an offset press. And computer screens can reproduce even more colours than an offset press or photographic paper. The human eye can perceive approximately 10 to 15 million colours. A computer screen can reproduce 16 million colours, and photographic paper around 10,000 to 15,000 colours. An offset press can reproduce from 5000 to 6000 colours in four-colour process.

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printed. We use these proofs to check the document through the various stages of production. Ultimately, the proof will serve as a guide for the press operator during printing. The proof also serves as a bridge between client and printer: it represents what the client wants and what the printer needs to reproduce on press. To be of use, a colour proof must reproduce the tones and general appearance of the document as faithfully as possible. Many factors may influence the accuracy of a colour proof – we will address these questions in a future issue of the Tech Bulletin.

METAMERISM

This is a phenomenon whereby two objects that appear identically coloured under one light source appear different under another type of lighting. The phenomenon of metamerism can be seen in the following example: the colour of your jacket seems to match perfectly the colour of your pants when you look at them under incandescent light. But the same outfit seems to clash in broad daylight. This is because the composition of the pigments in the dyes of the coat and the pants is not the same. If the two articles had been produced from the same fabric and using the same dyes, the problem of metamerism would not occur.

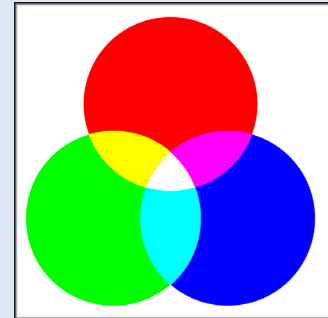
Metamerism can also cause problems in a pre-press environment. For instance, using a paper proof, and working under D50 lighting, we might find a CMYK recipe that would closely reproduce the colour of a given product. But the same CMYK recipe might also seem wrong under a different kind of lighting.

CONCLUSION

Standard lighting should definitely be used when verifying proofs. This will enable you to avoid problems that can lead to expensive on-press colour adjustments. You can set up a standardized light booth for proofing at relatively low cost. Your service supplier and printer should also be equipped with an area where proofs and printed material can be examined under standard lighting.

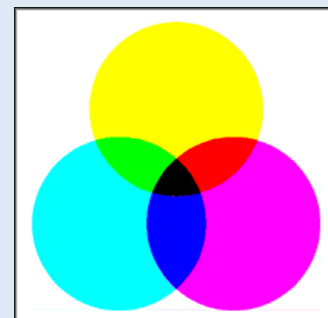
Additive Synthesis

This method is called “additive” because the sum of the three base colours (red, green and blue) at equal intensity results in white. This technique is used for stage lighting and for producing colour on computer screens.



Subtractive Synthesis

The “subtractive” method is the combination of the three base colours (cyan, magenta and yellow) at equal intensity, which results in black. Each of the three pigments absorbs the waves of a primary additive colour (red, green or blue) and reflects the waves of the other two. Because it is difficult to create pure cyan, magenta and yellow pigments, the combination of these three primary colours does not render a genuine black, but rather a dark brown. Since black plays a very important role in the composition of shadows, a fourth ink – black – is used in four-colour process printing.



Datachrome's team of colour specialists can offer you expert advice and guidance in a range of fields, including high-resolution scanning, photo retouching, large-format printing and offset printing.

