

A Simple Guide to Colour

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One of the most misunderstood areas of colour reproduction involves how to judge colour. In the following article I'll discuss some of the problems involved in colour reproduction. Understanding what can and can't be done will make dealing with printers, designers and photographers much easier. I've also included a section about evaluating digital images, colour prints and colour transparencies.

I've cut the theory down to the barest minimum and haven't included much in the way of detailed explanations. Still, due to the subject matter, even the bare minimum of material presented here may seem complicated. Should you need more in-depth treatment, consult the references at the end of this article.

Why bother learning the technical aspects of colour? Things have also changed drastically over the past few years. Prior to digital imagery, colour separation and pre-press were handled exclusively by specialists; all the client, photographer, graphic designer and art director were responsible for was approving the artwork and photography. Now the responsibility for colour has been shifted and it is our responsibility to ensure that the colour that comes off the press or appears on the web site is the colour that was expected.

Colour Basics

In this section I'll provide some of the definitions and technical terms used in describing the characteristics of colour images.

First we'll begin with a simple definition of colour. Colour is a physiological sensation; the brain interprets what the eye sees and this results in the sensation of colour. Human eyes see a narrow band of electromagnetic radiation, with wavelengths from roughly 400nm to 700nm (nanometers). For example, if a colour in nature reflects a light of predominately 550nm it will appear to our eyes as a green. Light sensitive cells in our eyes, called cones, respond to just three colours of light red, green and blue. All the colours that we see are a mixture of three signals. The ability of the eye to sense any colour in the visible spectrum using just three primary colours is called the trichromacy theory or the Young-Helmholz theory (named after the two scientists who formalized it Thomas Young in 1801 and Herman Ludwig Ferdinand von Helmholtz who later expanded the theory).

There is also a competing theory of colour vision called the opponent-colours theory which uses two perceptual hue dimensions; usually yellow/blue and red/green (although some other colour combinations work equally well) along with a brightness dimension of light/dark. The nerve cells in the human retina appear to

encode the three colour signals from the cones into opponent values. Although the opponent-colours theory may seem to be of only academic importance, it is the basis of several popular colour spaces (more about this later). The opponent-colours theory was first formalized by the German physiologist Karl Ewald Konstantin Hering about 1878.

A measure you'll often see used in imaging science is density. Density is a measure of the light-absorbing ability of a surface; a surface which reflects 100% of the light falling on it has a density of 0. Our eyes have a non-linear response to light and the measurement scale of density takes this into account by using logarithmic units. For example an area of a print that reflects 10% of the light has a density of 1.0, a reflection of 1% would give a density of 2.0 and so on. The dynamic range is the range from light to dark that a particular device can capture expressed in density units (abbreviated as D). A photographic print has a dynamic range of approximately 2.2D, a colour monitor of 2.4D and a photographic transparency of 3.8D. You'll often see the dynamic range listed on specifications for scanners and digital cameras.

Contrast, the number of tones between black and white, is often given as gamma. As gamma increases the number of steps between black and white decrease. Simply defined, gamma is the relationship between output and input in an imaging system. Film gamma uses density as output and relative exposure as input; video systems use video signal as input and screen luminance as output. For colour monitors a normal gamma seems to be around 2.0 (Apple monitors have a 1.8 gamma, Windows sRGB use a gamma of 2.2). Traditional black-and-white negative films have a gamma of about 0.8. Colour transparencies (sometimes called "slides" or "chromes") have a gamma approaching 3.0

How Colour Reproduction Works

Trichromacy is the key to colour reproduction. Our eyes only need information from three colours to form any colour and so it is a straightforward matter to create full colour images by using different combinations of red, green and blue light. In our three colour system, red, green and blue light combine to form white light. These are known as the additive primaries because they add together to form white light. Colour monitors for computers use the additive primaries to produce colour images; phosphors struck by an electron beam glow red, green and blue. You'll usually see additive colour

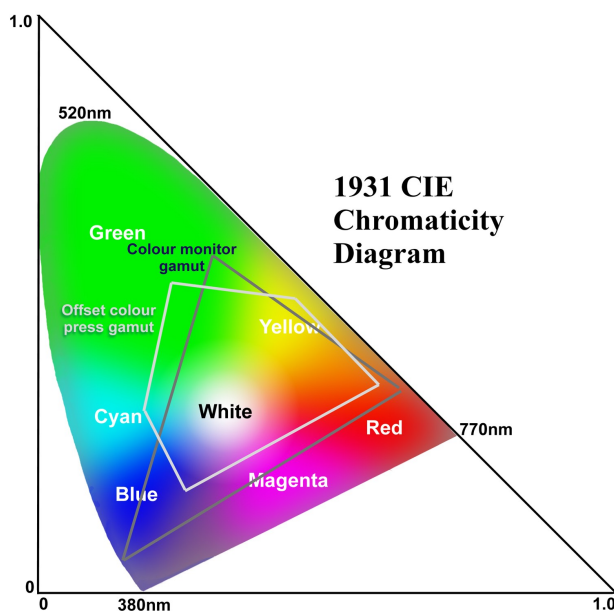


systems referred to as RGB for the three colours of light, Red, Green and Blue. Colour can also be created by subtracting colours from white light. Cyan, magenta and yellow dyes or pigments are the subtractive primaries and control the additive primaries by selective absorption; cyan absorbs red, magenta absorbs green and yellow absorbs blue light. Mix the three together and all of the light is absorbed resulting in black. ALL the colours you see in films and prints are a combination of these three subtractive primary colours. In practice pigments and dyes of cyan, magenta and yellow can only form a dark muddy gray when mixed so a fourth pigment, black, is used in most printing systems. Four colour printing is sometimes called process colour or four-colour process. Four colour systems are often referred to as CMYK for Cyan, Magenta, Yellow and black.

Three aspects of colour are:

- Hue** - The actual colour red, yellow, violet etc. May also be expressed as the dominant wavelength i.e. 640nm
- Saturation** - How pure the colour is.
- Brightness** - The quantity of light *as perceived by an observer*; it exists independently of colour.

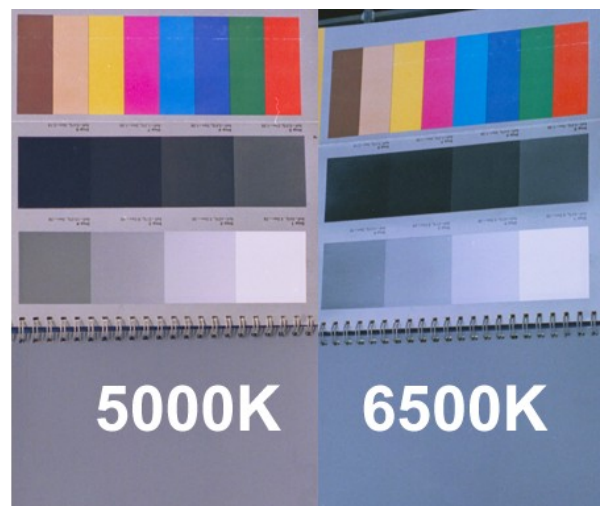
Colours exist in a space that is a combination of hue, saturation and brightness often called a colour space. The Commission Internationale de l'Eclairage (CIE) developed a perceptual colour space, published in 1931, which encompasses every colour the human eye can see. There are colour spaces for monitors based on the RGB colour model and colour spaces for printers based on the CMYK model; these colour spaces are subsets of the CIE colour space. There are other popular colour spaces



that you might run into; CIE LAB and CIE YCC. Both of these colour spaces are based on the opponent-colour theory of Hering. YCC is used for Kodak's Photo CD format and is based on video standards. The Y is luminance (a measure of the quantity of light independent of an observer), the two Cs are colour ranges from magenta to green and from yellow to blue. LAB is used in Adobe Photoshop and is a popular colour space in Europe. L is the lightness (brightness relative to a fixed white reference), A is a colour range from red to green, B is a colour range from blue to yellow. Both YCC and LAB are perceptual colour spaces taking into account the visual system's inherent non-linear response to colour.

Within a colour space are areas that a particular device can either see (in the case of cameras and scanners) or that the device can render (in the case of printing presses, printers and monitors). These areas of colour are called gamuts and each device has a slightly different one. A monitor will be able to display colours that a printing press is physically incapable of reproducing and vice versa. A typical colour monitor and colour offset press gamuts have been shown on the 1931 CIE Chromaticity Diagram on this page.

When you view a colour print or transparency, the light you use can affect the apparent colours that you see. While the light may look white, the spectral make up of light can vary considerably. Some types of light like sunlight are continuous spectra being made up of all wavelengths; other types of light such as neon lighting, sodium lights and fluorescent lights are discontinuous or spike spectra; some wavelengths of light are not present. The overall colour of a continuous spectral light source can be given by its colour temperature in Kelvin. The higher the colour temperature, the more bluish the light is, the lower the colour temperature the more reddish. A regular 100 watt light bulb is about 2800 Kelvin, sunlight is 5000 Kelvin and the light on an overcast day



is 6500 Kelvin or higher. An example of the effect of colour temperature can be seen photographs (previous page), taken on film balanced for 5000 Kelvin in 5000K and 6500K sources. The colour of daylight varies from hour to hour and season to season and is influenced by weather conditions. Human eyes adjust to the changing colour and can neutralize slight colour differences. Colour temperature is important in specifying the type of light that we use to view colour under so that all observers see the same thing. Two types of light you'll often see in photography and the graphic arts are D50 and D65 standards; 5000 Kelvin and 6500 Kelvin respectively but with carefully defined spectra. Different colours can sometimes match under one type of light not under another type of light; the phenomenon that causes this mismatch is called metamerism.

Problems in Colour Reproduction

We're all used to seeing colour and describing it in a casual way. Colour is subjective depending upon the viewer for interpretation; there is no absolute colour or right or wrong colour, only what the viewer sees.

A photograph can never record the exact colour of a scene. For example, if I have a yellow box sitting on a blue rug and I take a photograph of it, the image sensor, whether it is electronic or conventional film, will not record EXACTLY the colour of the box and rug. Saturation (purity of colour) and detail are lost. The reason for this is that no reproduction system is perfect. In a camera, the lens introduces a slight colour shift, stray light in the lens and in the camera interior degrades the quality of an image.

Human skin tones are "memory" colours; humans are sensitive to colour casts and off-colour skin tones more so than other colours. Still, the range of skin tones that people will accept as normal is quite large; a comparison the various skin tones in a high-end fashion magazine will bear this observation out. Neutral colours or tones (black, white, gray) are critical since these are very sensitive to colour shifts.

Analog copies of photographs using conventional film and lens systems lose saturation and gain contrast with each generation. Digital images can be copied multiple times without loss but this isn't the full story. If you're manipulating digital images, switching back and forth between different colour spaces when editing and saving will decrease the quality with each generation. As we've seen, the LAB, RGB and CMYK colour spaces are all slightly different and a small amount of information relating to colour is discarded each time an image is converted from one colour space to another. Some compression methods such as the JPEG compression are "lossy"; high-frequency information is

discarded during compression to create a smaller digital file size. Every time you edit and re-save an image with JPEG compression you lose information and decrease the quality of the image.

When working with images intended for colour offset printing, it is important to realize the physical limitations of the printing process. Decisions made during conversion between colour spaces may affect the final reproduction. The total ink limit must be set when converting from RGB to CMYK. In addition, under colour removal or gray component replacement might be used to reduce the amount of ink applied to the paper. If too much ink is applied it may not dry properly, appear oddly coloured or have plugged-up detail.

When the job is finally on the printing press, the inks, paper and press all affect the accuracy of the colour. colour inks are not pure, all contain contaminants which require corrections. Few papers are perfectly neutral in colour and the absorption and spreading of ink when it is applied to the paper affects the contrast and tonal scale of the image. Even the finish of the paper affects the image; a matte or rough surface decreases the contrast and tonal range of the image. These effects should be taken into consideration by the client, photographer and designer so that the piece is created specifically for a particular combination of paper, ink and reproduction technique.

These are just some of the many factors that create problems in colour reproduction. Exact colours may be difficult or impossible to reproduce and insisting on exact colour can increase the costs of a printing job dramatically. The best way of handling most colour jobs is to decide which colours are the most important and work towards reproducing these colours with as much accuracy as possible given the constraints of the budget and time. In most cases, barring technical problems, evaluating the success or failure of a colour reproduction is subjective.

Evaluating Digital Images, Colour Prints and Transparencies

In photography and the graphic arts we adhere to standards that reduce the variation between the colour we see in a print or transparency, in a proof or on a computer monitor and what we see coming off the press. There will always be problems with the different device gamuts since this will limit what colours can be displayed and what colours can be printed. By specifying the lighting used to view both the proofs and finished work we can make accurate predictions about how something will print. If the client, photographer and printer do not have a common colour standard there will be unwelcome surprises in the final printed piece.

Viewing prints and transparencies use the ISO 3664 Viewing Conditions - for Graphic Technology and Photography standards. Be aware that using just a 5000 Kelvin light is not good enough; the spectrum of the light must match the D50 standard and meet other critical specifications as well such as the luminance of the viewing surface and the colour of the surrounding area. When you purchase a viewing booth, insist that it be ISO 3664 compliant; it should say so on the booth.

ISO 3664 contains recommendations for viewing colour images on your computer monitor. If you intend to use a colour monitor for critical viewing or proofing (often called soft proofing) you should consult with a professional supplier to get a proper monitor and calibration equipment. For more casual viewing, set your monitor up to use the sRGB colour space (based on International Electrotechnical Commission IEC 61966-2-1 standard) designed around the phosphors used in current monitors. This is the current default for Microsoft Windows operating system.

Creating colour images for electronic publishing on the web or otherwise is always a crapshoot; most people don't bother to calibrate their monitors. Given that most of the client computers on the Internet are running the Windows operating system, using the sRGB colour space for your web images is your best option. Be aware that an image created for the sRGB colour space will most likely display with a lower contrast on a Mac. If you're intended target market is a group such as graphic designers or others that are liable to be Mac users you should take this into consideration.

Colour Management

If you've ever used a computer and printer to print out an image from the screen, you'll have experienced some of the problems involved in colour reproduction. Your print, most likely, didn't look like the image on the monitor; some colours looked darker, maybe the image took on an overall colour cast.

To get around these problems professionals use a colour management system. The goal of colour management is NOT colour correction but to give everyone involved in the colour reproduction process a consistent view of the image. Colour profiles make one device, lets say a monitor, produce the same colours, given gamut limitations, as that of another device; a printing press or a computer printer. Ideally, something scanned on a properly profiled scanner and viewed on an properly profiled monitor should appear close to the original. Although standard profiles may be available from the manufacturer, it is always best to have each device individually profiled. You can do this yourself or have a colour management consultant do it for you.

Effective colour management begins with the delivery of the image. Using guidelines such as UPDIG (Universal Photographic Digital Imaging Guidelines) ensures that the user will have enough information to properly view and evaluate the image.

The field of colour management is rapidly evolving and very complex; if you need more information concerning colour management see the bibliography (follows) or consult a professional

Finally, ALWAYS ask for and approve a colour proof BEFORE your job is printed. View the proof under standardized lighting conditions.

Bibliography

Want to learn more? I've listed a few books that you might find helpful.

For in-depth professional colour management read *Real World Color Management* by Bruce Fraser, Chris Murphy and Fred Bunting, published by Peachpit Press, Berkeley, California, 2003. I highly recommend this book to photographers, graphic artists and anyone else who deals with colour images on a daily basis.

The Complete Guide to Digital Color Correction by Michael Walker with Neil Barstow, published by Lark Books, New York, NY, 2004 is a well-written guide for photographers and designers working with color images. Provides practical examples of colour and tone correction using Adobe Photoshop.

Color for Science, Art and Technology edited by Kurt Nassau, published by Elsevier Science B.V., Amsterdam, The Netherlands, 1998. Introduction to the science of colour with in depth colour theory by colour experts in many fields. Not for the faint of heart!

Of interest to photographers, scientists and artists is *Color and light in nature - 2nd Edition* by David K. Lynch and William Livingston, published by Cambridge University Press, Cambridge, UK, 2001. Both authors are professional astronomers and they describe the vast range of light phenomena in nature. Excellent book, full of photos and easy to read.

A fascinating look at the culture and history of colour. *Colour, Travels Through the Paintbox* by Victoria Finlay, published by Sceptre, London, UK, 2002. At just under 500 pages this is a lengthy tome but easy to read and entertaining. The author travels the world in search of the origins of pigments and dyes; lapis lazuli, cochineal, mummy and much more.

Glossary

AM screening (Amplitude Modulation) A screening that has a regular pattern of dots, the dots varying in size to represent different shades. When reproducing process colour each individual AM screen must be rotated with respect to each other to minimize the formation of moiré patterns.

additive primaries Three light sources, usually red, blue and green light that together give the visual impression of white light. Computer monitors use additive primaries (phosphors) to create the colours displayed.

aliasing The production of low-frequency artifacts in a digitally captured image resulting from an improperly sampled high-frequency signal. The low-frequency artifacts are aliases; indistinguishable from other low-frequency information in the image. Can be seen in images as colour aliasing, as "staircasing" (jagged outline of high contrast edges) and as a moiré patterns.

analog Having continuous values. A conventional photographic system using film is an analog system.

anti-aliasing Techniques (physical or software-based) used to prevent or reduce the occurrence of artifacts caused by aliasing. In digital cameras an optical low-pass filter is often used to prevent aliasing (an anti-aliasing filter). Text is often anti-aliased by replacing some of the black pixels along the edges of the letters with gray to remove "staircasing" and give a smoother appearance to the edges of the letters.

artifact In a digital image, a distortion caused by the imaging system or subsequent image processing

banding The representation of a graduated tone as a series of bands with sharp breaks in the shading. Caused by the inability of the rendering system (monitor, printer) to reproduce all of the colours required for smooth shading.

bit A binary digit; single piece of information in a digital computer system. A bit may have a value of either 1 or 0 (base 2). You'll often see the term bit used in describing colour depth.

brightness The perceived light intensity by the human visual system. Brightness is logarithmic

byte 8 bits, which can express a value from 0 to 255 (256 values or 2^8)

chrome A colour transparency (positive colour image). Derived from the proprietary names of colour films; e.g. Kodachrome®, Agfachrome®

CMYK a four colour system (Cyan, Magenta, Yellow, and black), usually used in ink-based reproduction (e.g. printers, presses) and based on the subtractive primaries.

colour depth The number of shades of each component colour which can be described. A colour depth of 8 bits can have 256 shades ($2^8 = 256$), 12 bits can have 4096 shades ($2^{12} = 4096$). In an RGB image, the three

channels multiply to give the total number of colours for that system (i.e. 8 bits per channel $256 \times 256 \times 256 = 16777216$ colours). A greater colour depth results in a smoother transition between subtle variations in shading.

colour management The process of ensuring consistent colour between input (e.g. camera, scanner) and output (e.g. monitor, printing press) in an imaging system

colour separation The process of separating a colour image into its component colours for printing.

colour space The total possible range of colours that can be expressed in the image.

colour temperature The mix of wavelengths that a light source emits. In general, the lower the colour temperature the more reddish the source appears, the higher the colour temperature the source appears more bluish. Colour temperature is measured using the metric unit Kelvin. When used in reference to colour temperature, Kelvin refers to the colour of light emitted by a black-body at that temperature (all objects above absolute zero emit electromagnetic radiation). See Kelvin

contract proof A proof that shows how the printed piece will actually look. It is approved and signed by the client hence the term "contract."

contrast The number of intermediate steps or gray values between black and white. A high contrast image will have very few values (e.g. a pen and ink sketch) a low contrast image will have many values

C-print A photographic colour print produced with a traditional film-based system and chemically processed.

cross render Simulating the output of one device on another output device. For example, proofing a job to be run on an offset press by using the profile of the press AND the profile of an inkjet printer to make a proof on the inkjet printer.

density The amount of light a medium absorbs. The greater the density the more light the medium absorbs. Density is a logarithmic unit and is usually abbreviated as D.

digital Having discrete values, usually stored or manipulated numerically as bits or bytes. A CD player is a digital system (although the final output is analog sound).

digital negative (DNG) An open (publicly available) archival format created by Adobe® to standardize digital image processing, manipulation and archiving. The digital negative is lossless and retains all or most of the information in the original raw file.

digital processing Colour balance, gamma, colour space and other corrections performed on the original RAW camera file and then output in a non-proprietary format (e.g. TIFF, JPEG). Digital processing corrections are global (corrections affect the entire image) rather than local (local corrections

- are usually referred to as retouching). Roughly equivalent to processing film in the analog realm.
- dpi** (dots per inch) The resolution of printer output, not to be confused with ppi (pixels per inch)
- editing** Sorting images, digital or otherwise, into various categories (e.g. usable/unusable). This term is often used, incorrectly, as a synonym for retouching.
- Exif** (Exchangeable Image file Format) A common format for storing image information (e.g. camera make and model, exposure) within the image file.
- fluorescence** A process in which light of one wavelength is absorbed by a substance and the energy emitted as a different wavelength. Fluorescence often poses a problem when photographing a paper or cloth treated with a whitening agent; white areas lose texture due to the fluorescence of the whitening agent.
- FM screening** (Frequency Modulation) A screening in which all dots are of the same size but vary in spatial frequency (number of dots per area).
- four colour process** see process colour
- frequency** The number of waves, vibrations, cycles or changes over a given interval. In common use, frequency refers to a time interval. The SI unit of frequency is hertz (Hz) or cycles per second. Frequency may also refer to spatial frequency which is the change over a given space.
- gamma** In simple terms gamma is the relationship of input to output in a visual system, usually expressed as a single number. For monitors, gamma is input voltage signal to output intensity, for film gamma is input luminance to output density. The higher the gamma, the higher the contrast.
- gamut** The range of colours that a particular device (e.g. a camera or monitor) can capture or display
- GIMP** An image manipulation program, the GNU Image Manipulation Program, available under the GNU General Public License (GNU is a free software project started by Richard Stallman). It is similar, in many respects, to Photoshop® by Adobe®.
- GRACoL** (General Requirements for Applications in Commercial offset Lithography) Printing guidelines for commercial printers. Similar to SWOP.
- Gray Component Replacement** (GCR) Replaces areas where cyan, magenta and yellow are printed with an equivalent amount of black ink replacing the neutral gray formed by the CMY inks. This reduces the overall amount of ink on the paper and makes it easier to achieve a gray balance on the press.
- guide print** A print provided by a photographer or artist that shows how the digital image is meant to look. Not intended as a proof or contract print.
- halftone** A screened image made up of tiny dots so that when it is view at at normal viewing distance the dots merge to form a continuous tone.
- hue** The colour or dominate wavelength of light
- ICC profile** Information that allows a colour management system to convert colours to or from a colour space and the gamut of a specific device. There are generic ICC profiles for monitors, cameras, scanners and printers or a custom ICC profile may be created for a specific device. The ICC is the International Color Consortium; a group of companies that have created standards relating to colour management systems.
- ink limit** When printing a colour image on an offset press there is a limit to the total amount of ink that can be applied to the paper; this is called the total ink limit and is usually 300% with no more than a single colour printing at 100%. There is a black ink limit (determines shadow detail) of 70% to 90%
- JPEG** (Joint Photographic Experts Group) An image compression method specifically designed to compress photographic images by discarding low frequency information (e.g. textures). This compression technique can sometimes produce annoying artifacts, especially if an image is compressed repeatedly or if highly compressed. JPEG is not a file format; the "JPEG" files you use are actually the JFIF format (JPEG File Interchange Format) developed by an independent group.
- Kelvin** A temperature scale that begins at absolute zero Celsius (-273° Celsius) with each degree equivalent to one Celsius degree. The unit Kelvin is a capital K.
- linear** A one-to-one relationship between an input and output to a system
- logarithmic** A scale of measurement that is non-linear. Logarithms rely on a fixed base number raised to the power of an exponent (the logarithm). Usually the base of the logarithm is either 10 (the common logarithm) or e (a transcendental number approximately 2.718, also known as the natural logarithm). The common logarithm is used in brightness and density scales. For example 1.0 is 10 units ($10^1 = 100$), 2.0 is 100 units ($10^2 = 100$), 3.0 is 1000 units ($10^3 = 1000$) and so on. See brightness and density.
- lpi** (lines per inch) The resolution of the screen used in creating a halftone or screened image for printing on an offset press. See screening, offset lithography
- luminance** The amount of light emitted by a source independent of the viewer (see brightness)
- metamerism** When two colour samples with different spectral properties, appear the same under one light source but appear different under another light source this is metamerism. This effect has to do with the way the human visual system perceives colour.
- moiré** An interference pattern caused when two regular spatial patterns overlap (e.g. metal screens, cloth with an open weave). Moiré patterns can cause problems when a woven cloth in the photograph and the matrix of digital image sensor interfere with one another (moiré aliasing). Re-screening an image that has already been screened for reproduction can also introduce a moiré. The word moiré comes from the

French word for mohair, a fuzzy type of wool, which resembles the moiré patterns.

Munsell color system A colour specification system developed by Albert H. Munsell and first published in 1905. Munsell's system was a perceptual colour system based on the Munsell value (lightness), hue and chroma (the intensity of the colour).

offset lithography A type of printing process, dominant in commercial printing. Lithography uses an ink-receptive image on a water-receptive plate. This plate is dampened with a water-based fountain solution and a grease-based ink applied. The ink adheres only to the image areas. The ink is transferred to a rubber blanket and from the blanket to the paper.

opponent-colours theory A theory of colour vision based upon two perceptual hue dimensions of opposing colours; usually yellow/blue and red/green. There is also a brightness dimension of light/dark. The opponent-colour theory is the basis of several popular colour spaces; e.g. LAB, YCC

Pantone® An easy-to-use colour specifying system based on printed colour swatches. Used by designers to specify solid colours. Pre-mixed inks and ink colour mixing guides for printers are part of the Pantone® system.

PDF (Portable Document Format) A format developed by Adobe Systems used to package files containing type, graphics and images for display or printing.

PDF/X A subset of the PDF specification developed by the Committee for Graphic Arts Technologies Standards for the delivery of documents for printing. The PDF/X is an ISO standard. To comply with the PDF/X standard a document must have all fonts and images embedded, the colour, CMYK, spot colour or grayscale and the output intent specified.

ppi (pixels per inch) The resolution of the actual image; sometimes confused with dpi (dots per inch)

process colour Colour offset printing using CMYK separations. Also called four-colour process.

raw (also RAW) An image from a digital camera, usually in a proprietary format, that contains all the original information from the image sensor in the camera and has not been processed. Raw camera files need to be processed using specialized software to create a usable image.

rendering intent The way a colour management system translates the colours in a large colour space to a smaller gamut. Since many devices cannot display all the colours in an image the rendering intent describes how the out-of-gamut colours will be displayed.

retouching Manipulating/replacing portions of an image to correct flaws or to create a particular "look" desired by the photographer. Retouching is sometimes, incorrectly, called editing.

RGB (Red, Green, Blue) A three-colour system based on the additive primaries.

saturation The purity of the hue or colour. A more saturated colour has a greater proportion of the dominant wavelength than a less saturated colour.

screening To reproduce a range of shades on a printing press or a printer, the inks used to print an image must be broken down into tiny dots that from normal viewing distance merge to give the impression of a smooth shade. The process of creating these tiny dots, whether analog or digital, is called screening.

soft proof The use of a colour monitor for proofing an image instead of a printed (hard copy) proof

spotting Removal of defects caused by dust or film processing in a print. Usually done on the print or negative with brush and dyes or a special pencil. This term may also be used in reference to digital removal of dust spots with a program like Photoshop®.

stochastic screening A type of FM screening that randomly distributes the halftone dots. Reduces problems caused by moiré patterns.

subtractive primaries Three colours (usually dyes or pigments) that absorb the additive primaries and create various colours. When mixed together the subtractive primaries look black. Colour printers use the subtractive primaries, cyan, magenta and yellow (along with black) to reproduce full-colour images.

SWOP (Specifications for Web Offset Publications) SWOP is a wide ranging specification for printing web publications; that include colour management and colour proofing. Web offset is a type of printing press that prints on a continuous strip of paper ("web") using the offset lithographic method of printing. Some ICC profiles are available (e.g. USWebCoated from Adobe® Systems) that conform to SWOP. Since SWOP is so widely available many printers, even those not printing web, use it.

TIFF (Tagged Image Field Format) A versatile image file format in widespread use. TIFF can encode an image in either RGB or CMYK, with or without compression (using one of several compression methods). Other information including Exif and ICC profiles can be stored in the TIFF file as well. Many graphics and publishing programs use TIFF files.

total ink limit see ink limit

trichromacy A theory of colour vision based on the perception of colour as composed of various amounts of red, green and blue light.

Under Colour Addition (UCA) Removing black from some of the darker shadow areas and replacing it with cyan, magenta and yellow inks. When carefully done this can result in deeper, richer shadows.

Under Colour Removal (UCR) In areas where cyan, magenta and yellow form a gray, the colour inks are reduced and replaced with black. This is done by modifying the separations. UCR helps in ink limiting while producing a denser black. If overdone UCR can leave shadow areas looking flat and low contrast.

UPDIG (Universal Photographic Digital Imaging Guidelines) A set of guidelines for the delivery and management of digital photography files.

white point The colour and intensity of the brightest white (no texture) reproducible by an output device. For a device such a monitor which emits light, the white point will be described in terms of colour temperature and luminance.

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