

PRINTING & COLOUR MANAGEMENT

COLOUR PERCEPTION, MODELS, PROFILES, AND SPACES

VISIBLE SPECTRUM & WAVELENGTHS

What is colour? Similar to sound, it's a measure of electromagnetic waves.

These waves are within a frequency that our eyes can perceive.

Wavelengths are measured in picometers (pm), nanometers (nm), micrometers (μm), millimeters (mm), meters (m), kilometers (km), and megameters (Mm). Colours are measured in nanometers.

VISIBLE/SPECTRAL COLOURS

X-RAY (100 PM-10NM)

ULTRAVIOLET (120-380)

VIOLET (380-450)

BLUE (450-485)

CYAN (485-500)

GREEN (500-565)

YELLOW (565-590)

ORANGE (590-625)

RED (625-750)

INFRARED (1-100 μm)

MICROWAVES (1mm-1m)

COLOUR PERCEPTION: TWO THEORIES

TRICHROMATIC THEORY

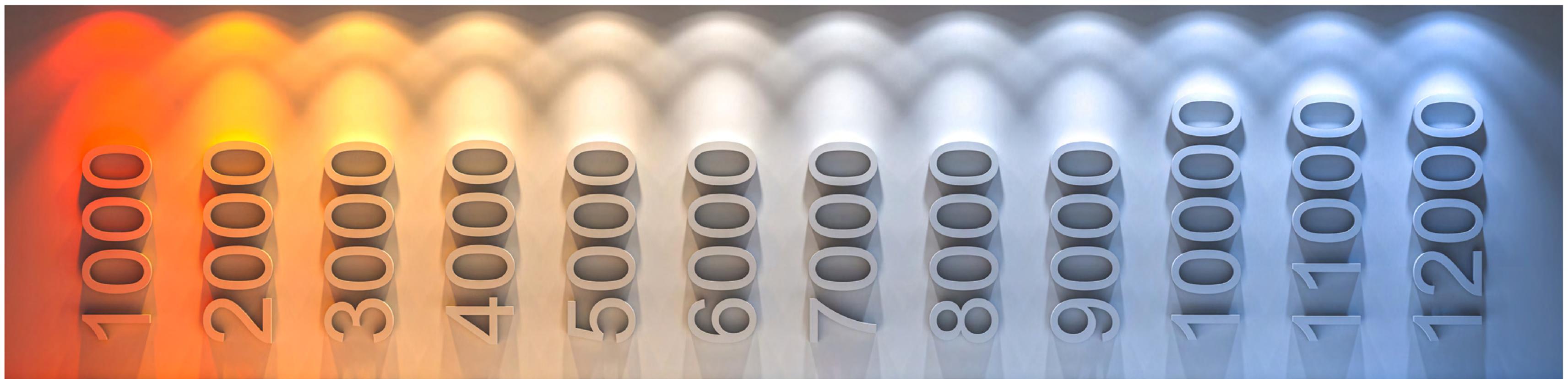
This is the theory many of us learned in grade school. In the retina, there are a variety of rods and cones. The rods help us perceive light, while the three types of cones help us perceive either green, blue, or red light. These three colours of light combined make up all of the visible spectrum of colours we know of.

OPPONENT PROCESS THEORY OR COMPLEMENTARY COLOUR THEORY

This theory is that the three types of cones have opposing processes (blue-yellow, red-cyan, and green-magenta). The theory is that these receptors cannot perceive both at the same time, which is why you can't see yellowish blue or reddish green.

LIGHT & COLOUR PERCEPTION

The way we perceive colour is integral to design, as it can completely change how a finished product looks. This is relevant to both the beginning of the design process and the end of it. White light contains all the wavelengths we perceive as colour. When light hits something, that thing absorbs some of the wavelengths of light and reflects others, allowing us to see colour. We measure the original wavelengths of light by using Kelvins (K), which is actually a unit of temperature measurement. We review print proofs in 3500-5000K conditions (more on this later).



COLOUR MODELS VS COLOUR SPACES

A color model is a mathematical model that helps us to define and describe colors through numerical values. Models are often able to be visualized in three dimensions.

This is all very math-y. Look up any Wiki page related to these slides and you'll likely find a handful of complicated mathematical formulas (most are transfer functions).

The model is the number we use to represent a specific colour in a digital system (like InDesign) and the math to determine that colour, where the space is the practical application of that colour model.

COLOUR MODELS VS COLOUR SPACES PT. 2

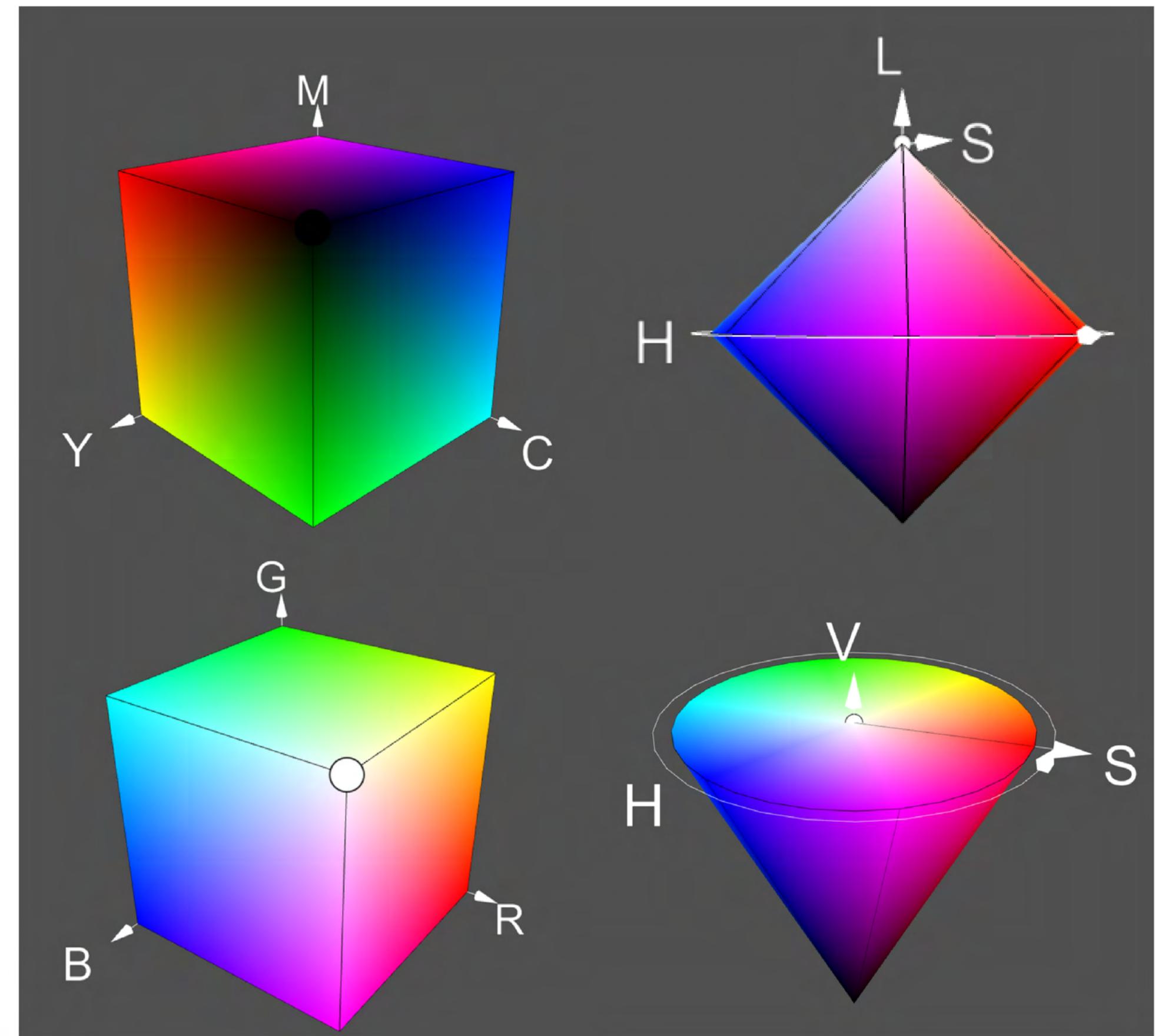
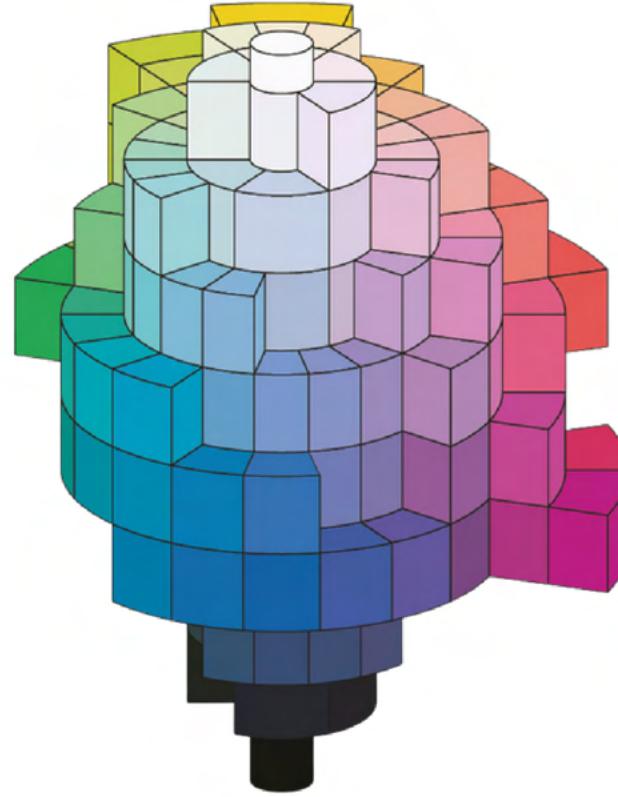
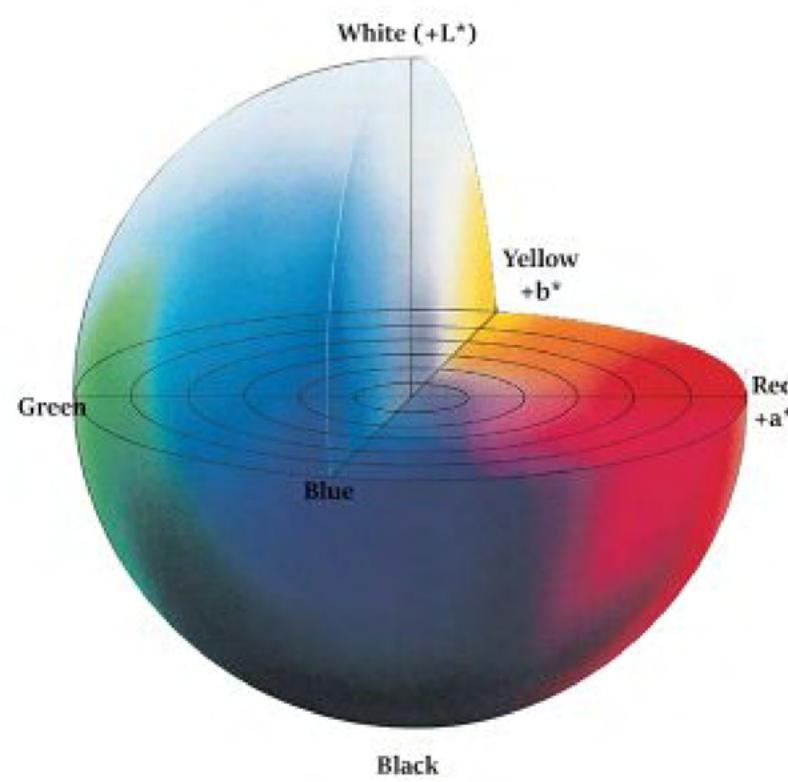
So if the model is the co-ordinates, the space is the organization of possible representations of colours. RGB is a model that can be used with a variety of spaces (sRGB etc.), where Pantone is a space without a model, as it doesn't relate to any particular mathematical formula or code structure.

COLOUR MODEL = THEORY

COLOUR SPACE = APPLICATION

COLOUR MODELS AS MODELS

Mathematical models can often be built into geometric representations. We can see on the right RGB, CMY, HSL, and HVS, and below we can see CIE. Other models include RGBA, CMYK, CAM, and YUV.

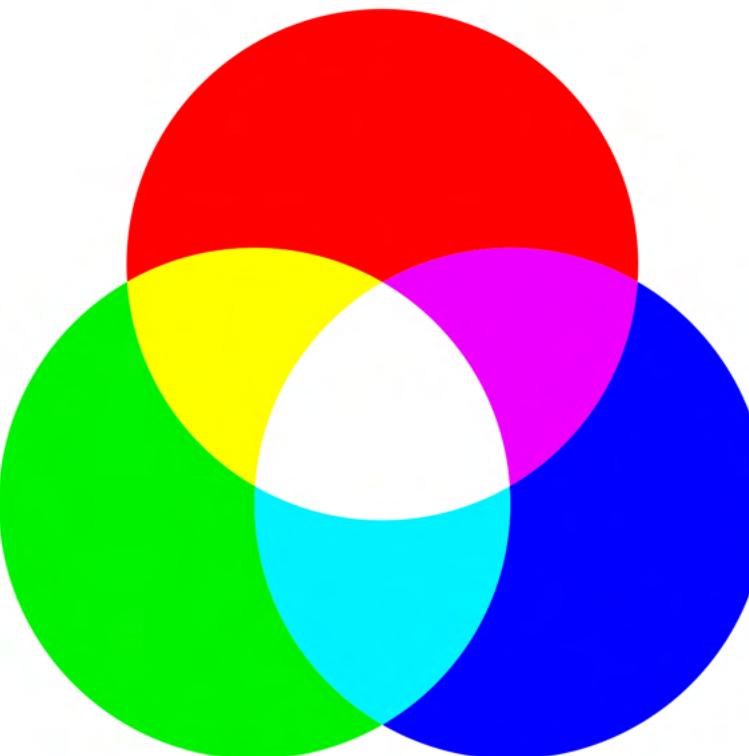


ADDITIVE OR SUBTRACTIVE?

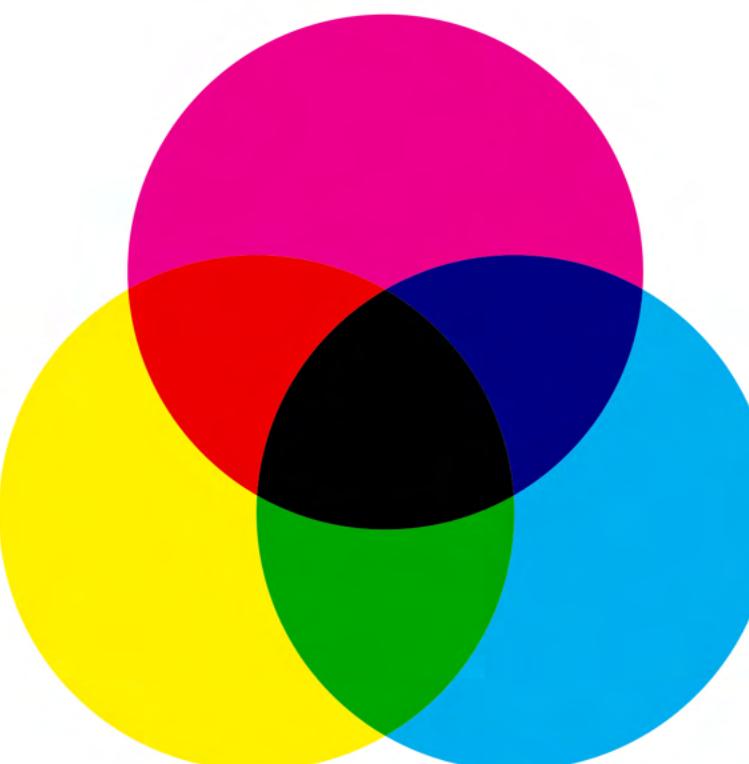
There are additive (light-emitting) or subtractive (surface color) models, and two of the most common models are RGB (additive) and CMY (subtractive).

- Additive models use light to produce colour
- Subtractive models absorb light

Since light is the basis for our perception of colour, it can be difficult to translate that light-based system to pigments and designs in a direct way.



RGB



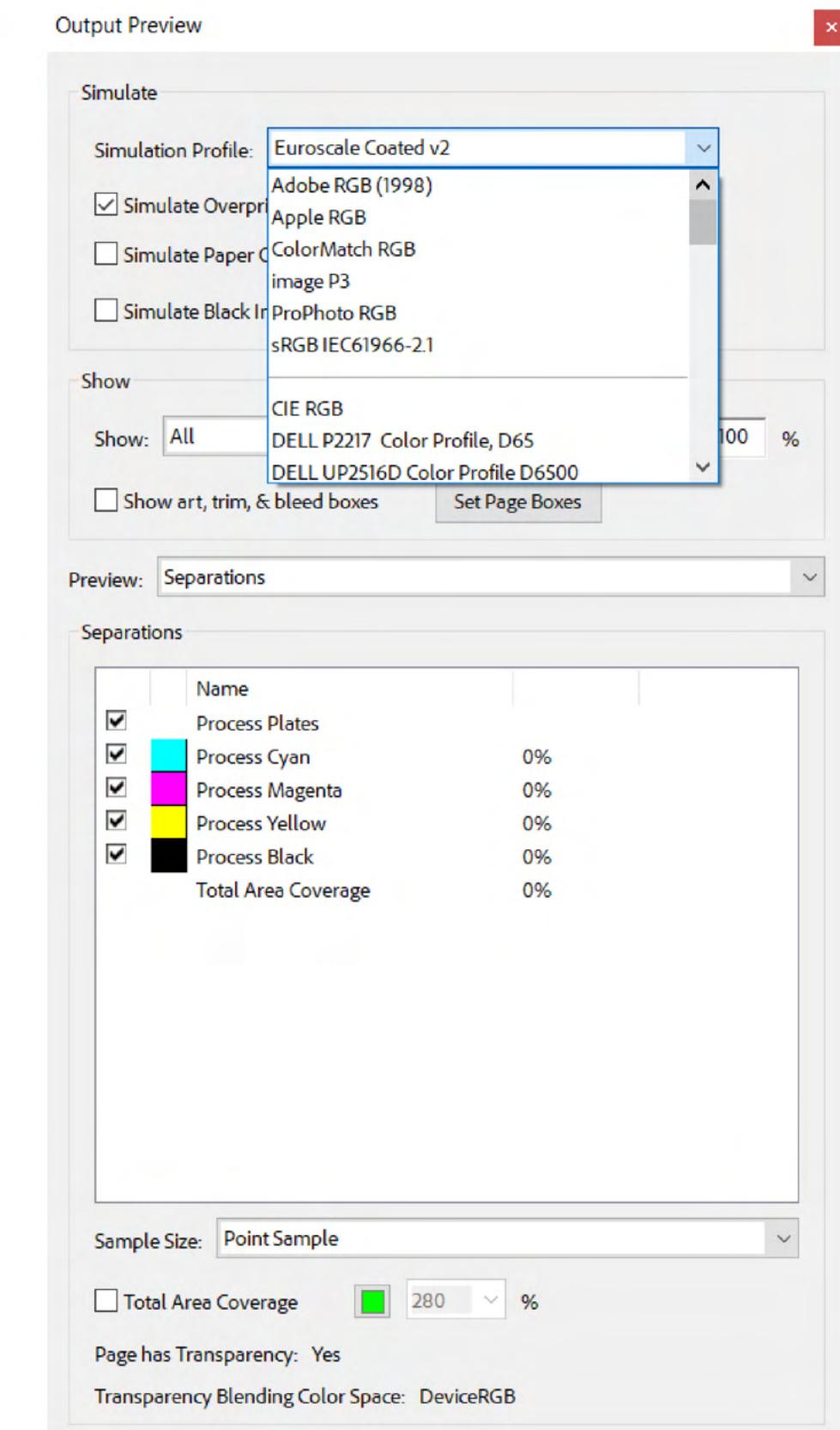
CMY

COLOUR SPACES VS COLOUR PROFILES

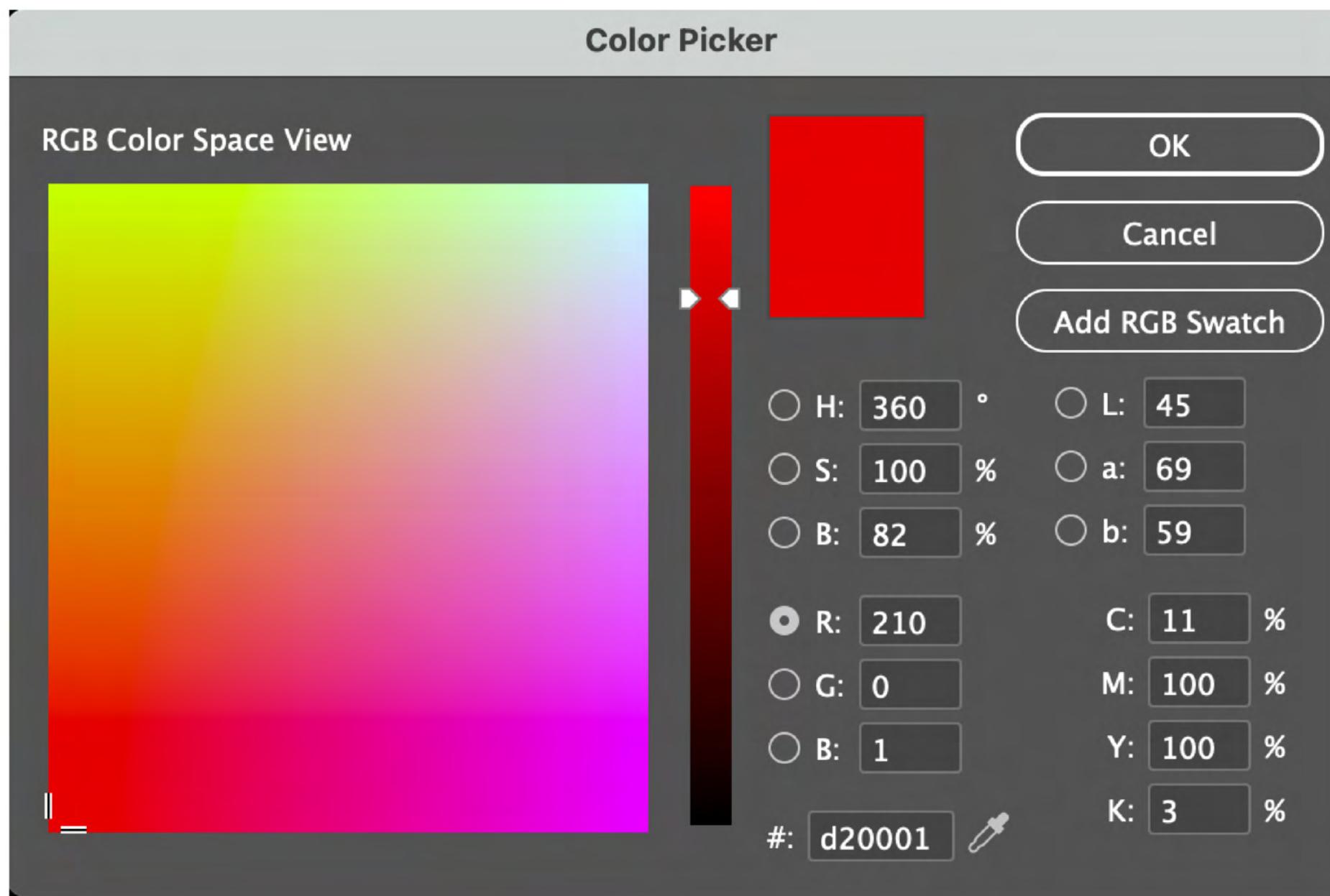
If a colour model is a mathematical method of understanding colour, and a colour space is the specific application of colours to those numbers, what is a colour profile?

If we're just dealing with colours as abstract concepts, we don't need a colour profile. However, most of us use colours practically in design or printing. Every device reads colours a bit differently, and so a colour profile is a way to manage colours and keep them consistent across devices.

By opening up PDF Output Preview, we can see an example of some colour profiles available to us.



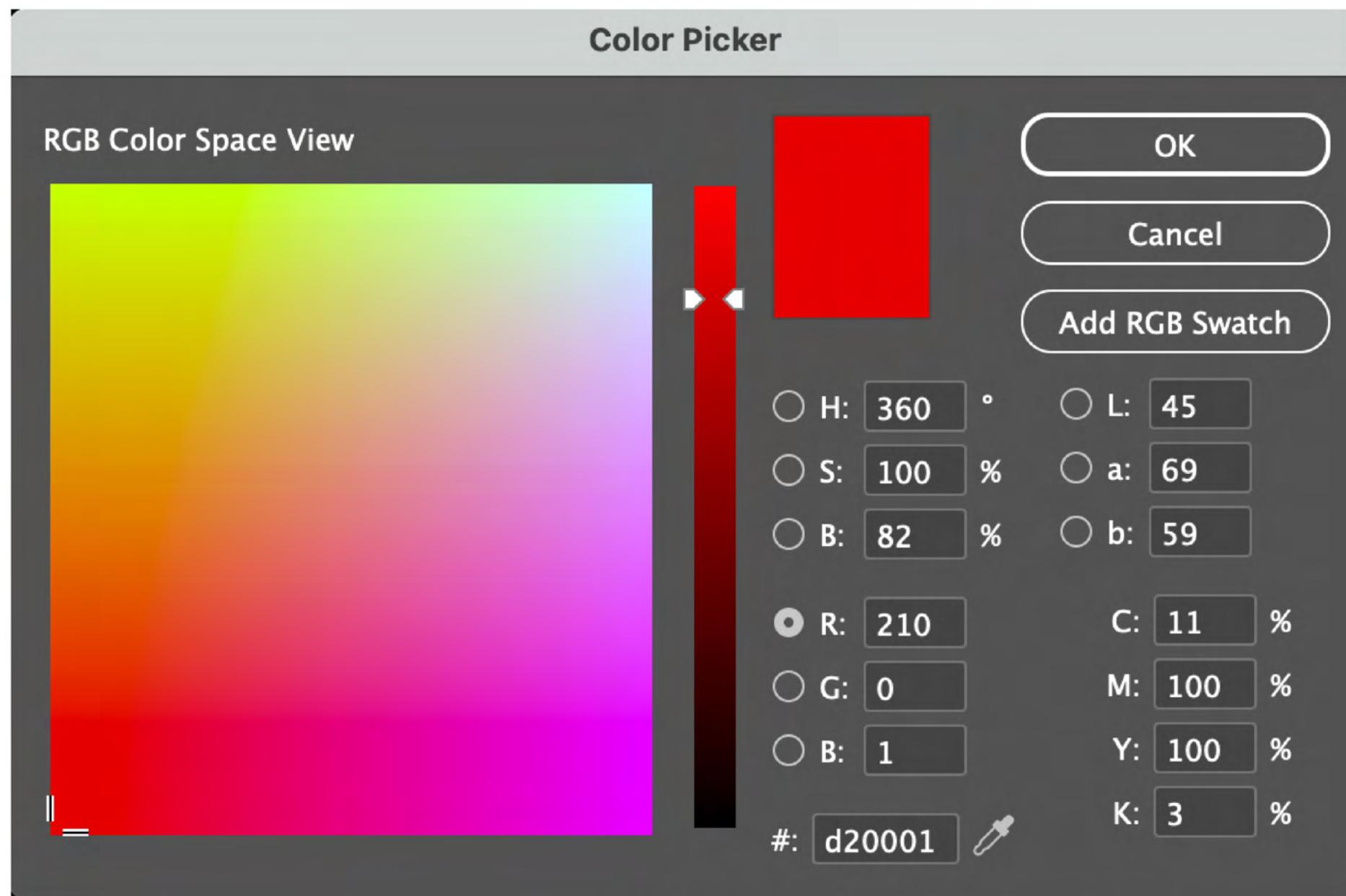
COLOUR SPACES & MODELS



Let's look at the InDesign Colour Picker Screen. Here we can see options to choose colours based on four colour models:

- HSB Model: Hue, Saturation, Brightness
- RGB Model: Red, Green, Blue (using sRGB colour space)
- Lab System: Lightness, Red/Green Value, Blue/Yellow Value (based on CIE model)
- CMYK System: Cyan, Magenta, Yellow, Key (based on CMY model)

COLOUR SPACES & MODELS CONTINUED



Still confused about the difference between colour models and colour spaces? Look at this chart again. Each of these four models are calculated using a different mathematical code. InDesign needed to show all four because you couldn't change the "R" (red) code in Lab, or the "H" (hue) code in HSB to the same effect. This colour picker is excellent at translating colour models, but we'll need to look at other settings to determine the colour space.

TRANSFER FUNCTION AS IT RELATES TO COLOUR SPACE

A transfer function is a math formula that describes how a code value relates to light energy input or output so you can translate one colour space to another as accurately as possible.

An RGB colour space, as outlined in the international standard ISO 22028-1:2016 must specify:

- A transfer function or a set of transfer functions
- Three chromaticities for each of the three primary lights
- The chromaticity of the white point

Since every colour space is defined by a formula (and each formula is quite different) it can be difficult to come up with the exact same colour when translating between spaces.

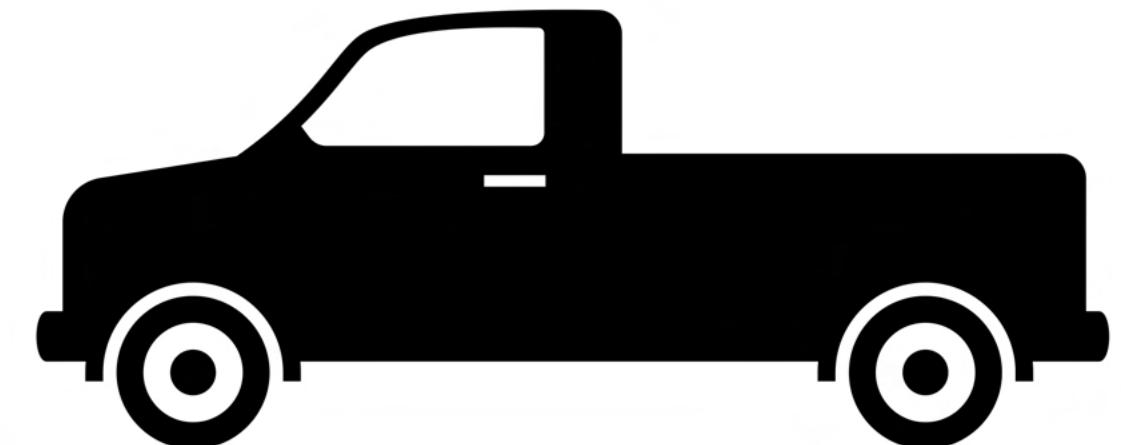
A LOOSELY-ACCURATE ANALOGY WITH TRUCKS

COLOUR MODEL TELLS US IT'S A TRUCK.

COLOUR SPACE TELLS US IT'S A TOYOTA TACOMA

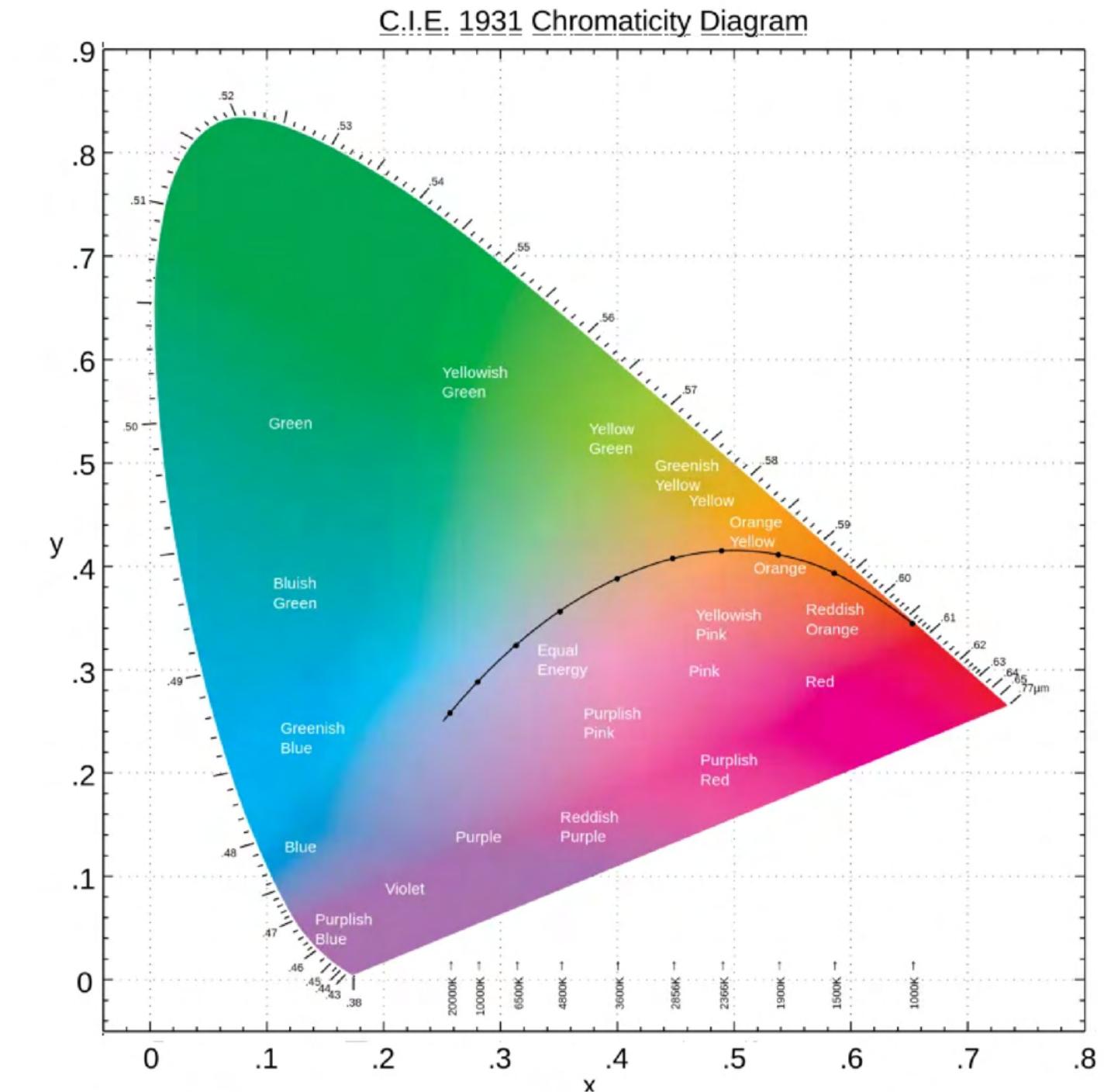
COLOR PROFILE TELLS US IT'S A GREY TOYOTA TACOMA 2022 TRD

In this analogy, if we're asked to describe the truck to someone, we can in varying levels of detail. We can estimate some things at first; we know the rough size and shape of a truck. Once we know all of the details, it's still a truck, we can just get a lot more specific in our description.



CIE COLOUR MODEL

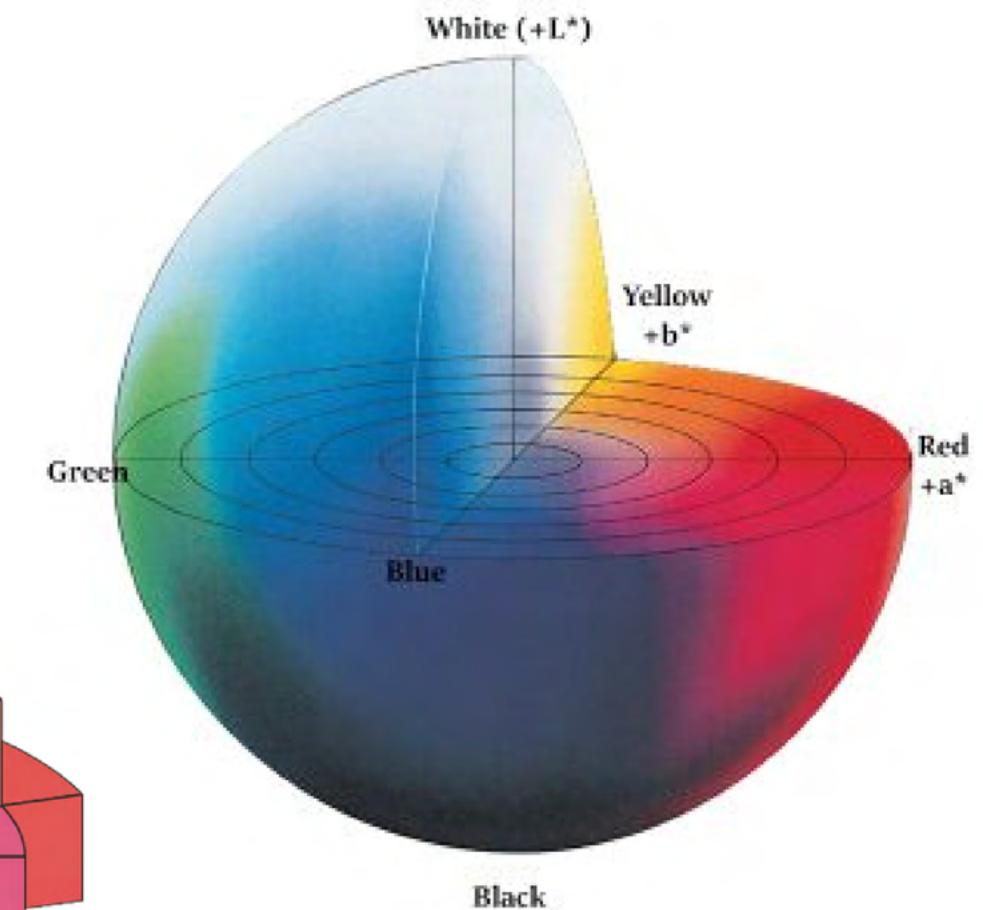
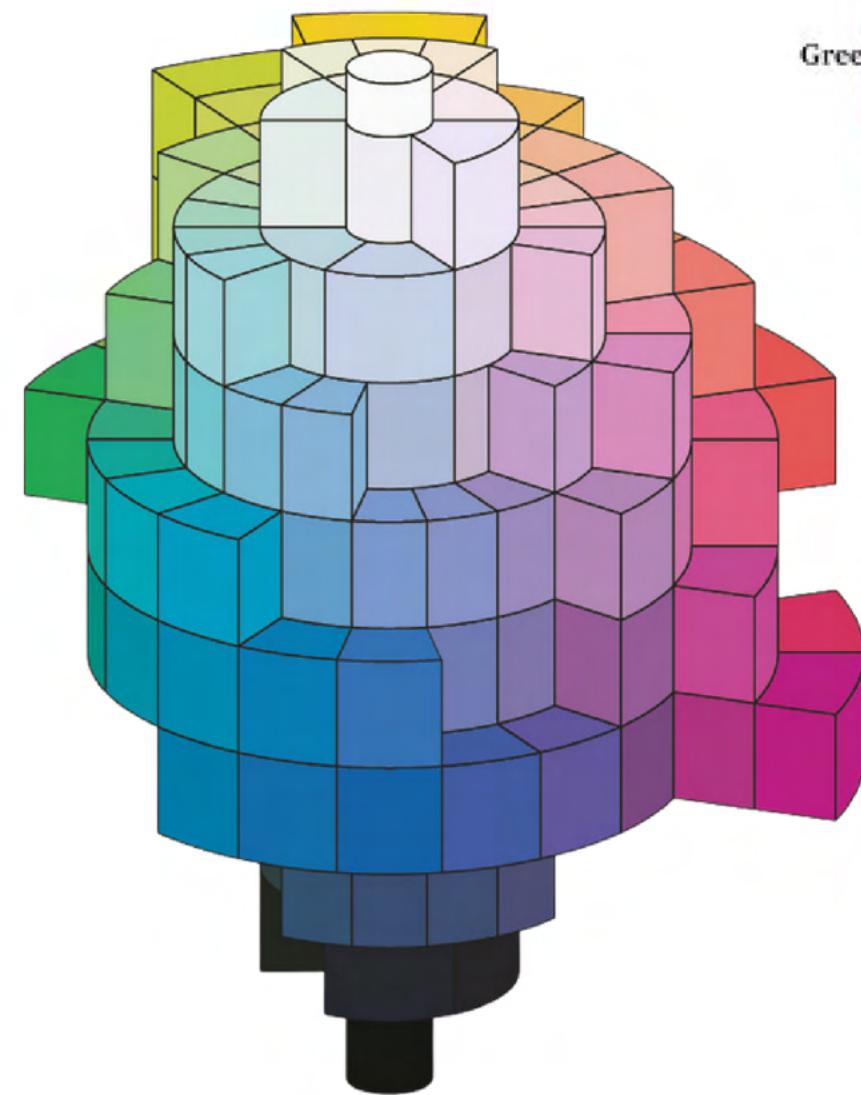
CIE is a colour model. The colour model is a mapping system that uses three values (highly saturated versions of red, green, and violet) and maps them in a three-dimensional space. This is one colour model that supposedly can represent every colour we can perceive. Unlike other colour models that are named after the elements they measure, this is named after the organization that researched it: the Commission Internationale de l'Elcairage (CIE, or International Commission on Illumination).



CIELAB AND CIELUV

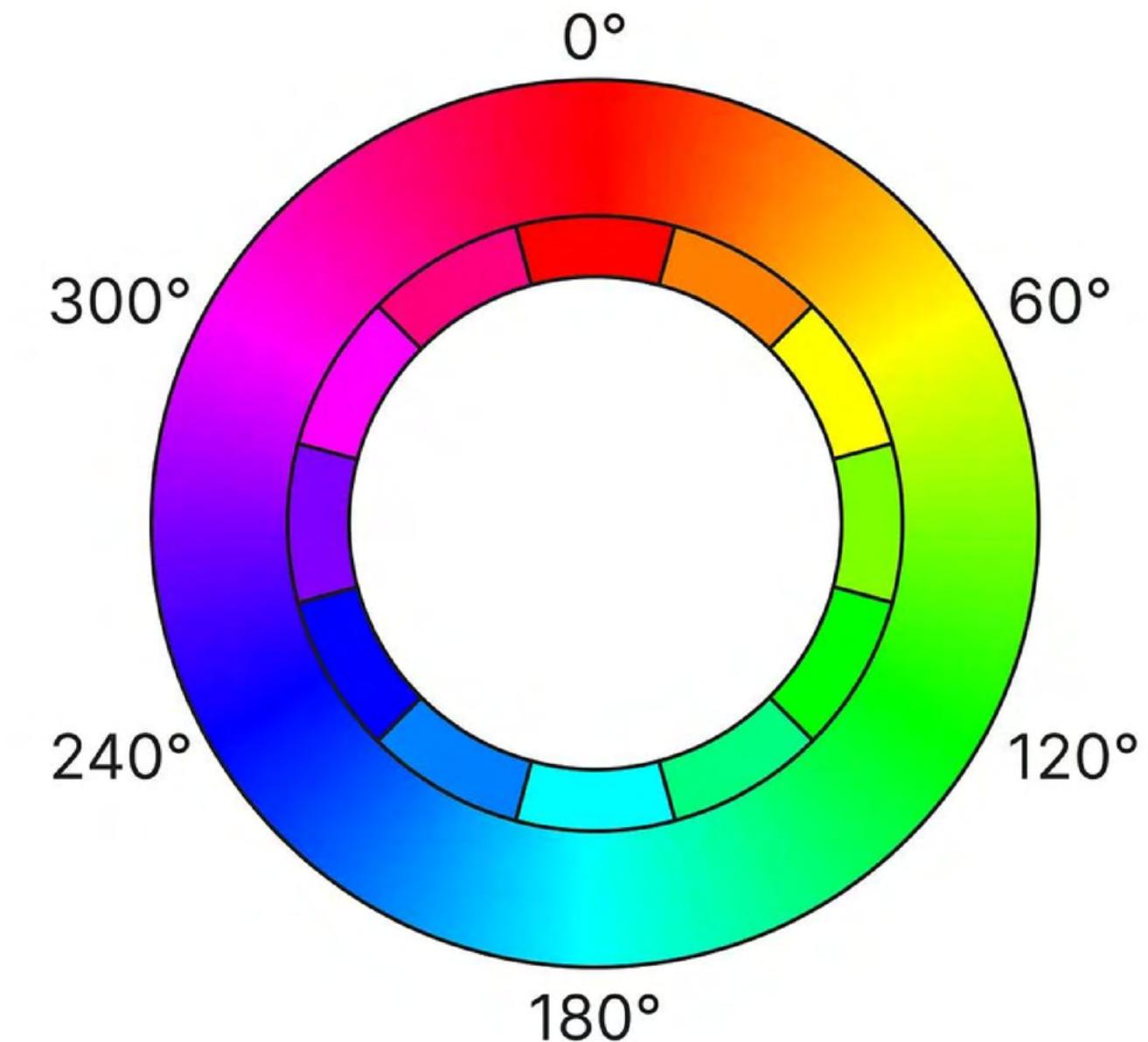
The CIE model was developed in 1931, and in 1976 two new models were introduced. CIELAB is a subtractive model (such as printing) and CIELUV is an additive colour model (such as digital images).

The L in Lab refers to lightness where the ab refer to two opponents (green-red and blue-yellow) in our vision. Remember the opponent process theory of colour earlier? This is the colour model that represents this best.



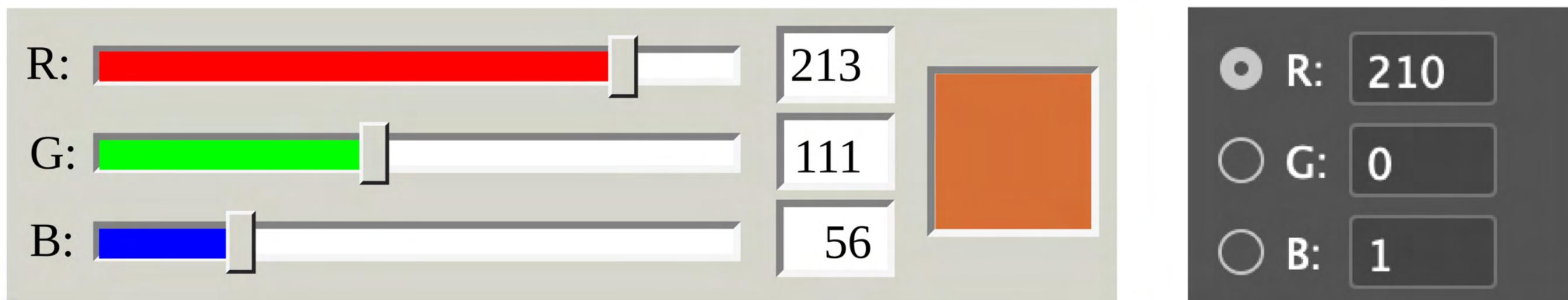
HSB/HSV COLOUR MODEL

HSB stands for Hue, Saturation, Brightness (aka, Value). This colour model uses an additive process just like RGB, and it represents colour on a colour wheel to determine the hue (360 options; see the degree sign in the InDesign chart?). Red is 0° & 360° , Green is 120° , and Blue is 240° . Saturation (vivid colour v. grey) and brightness (or value) are represented as percentages.



RGB COLOUR MODEL & HEX CODES

RGB is a colour model that changes the levels of Red, Green, and Blue on a sliding scale between 0-255 (the range of a single 8-bit byte). There are uses of this model that allow for a greater range, adding colours between these options (up to 64-bit, which allows each colour to be a range between 0-4,294,967,295). If you see a percentage-based slider, you may have a different bit channel. Why are these all considered the same colour model? The difference between bit channels is like moving the decimal point in an equation, not changing the equation. You can use any of several RGB colour spaces with this.

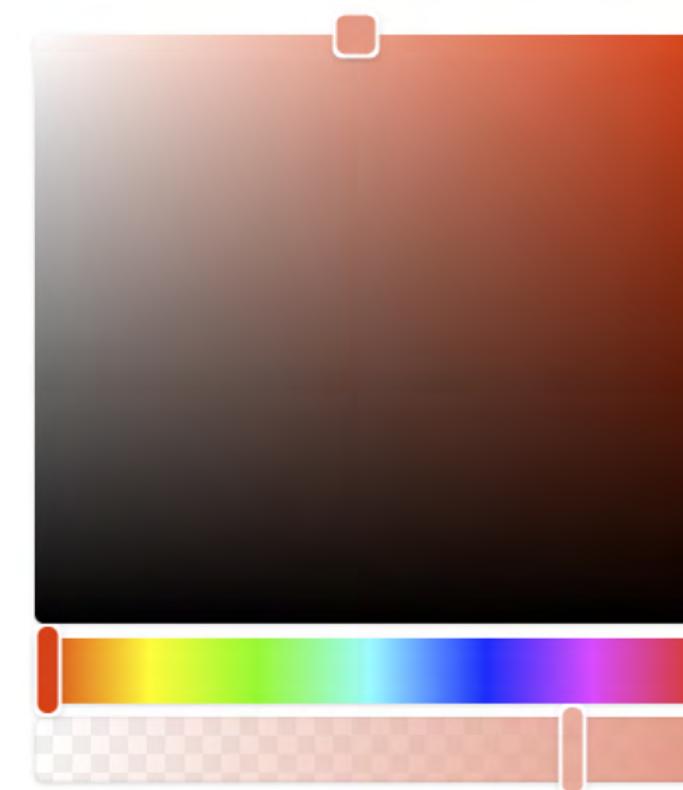
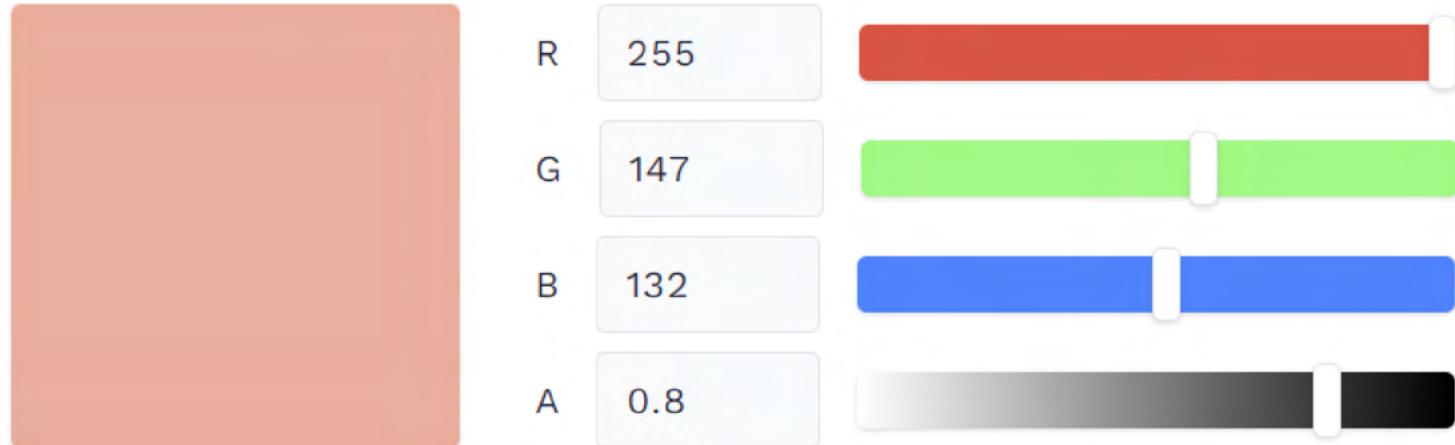


RGBA COLOUR MODEL

RGB stands for red, green, blue, alpha. This is essentially a duplicate of the RGB model with the addition of opacity (alpha) in the equation. You can use this model with the majority of RGB colour spaces, but it's a slightly larger file.

Think of a PNG image versus a JPG image. The PNG can have a transparent background, and it uses an RGBA colour model. A JPG uses a CIE colour model (which doesn't have transparency as an element).

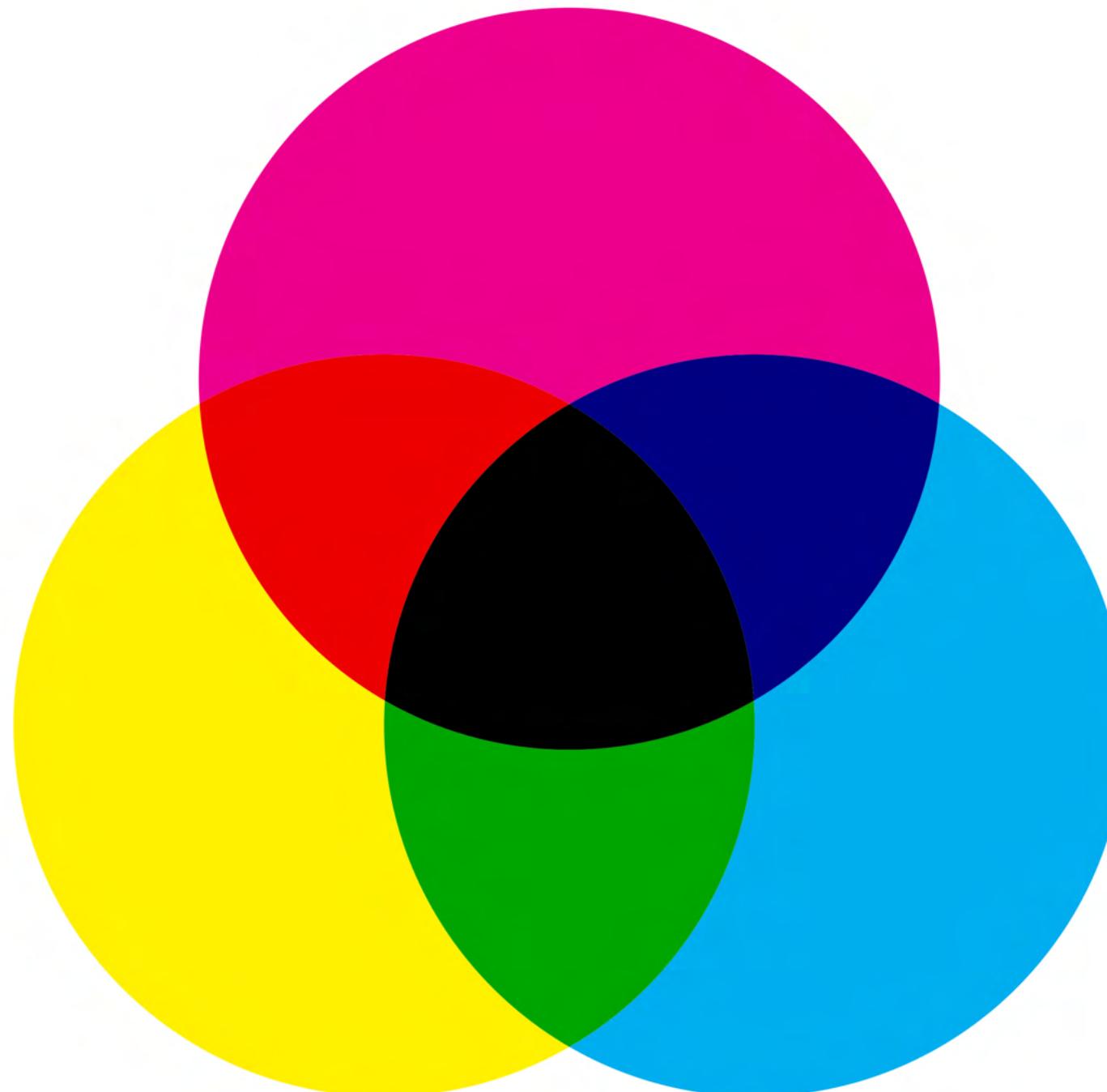
rgba(255, 147, 132, 0.8) 



CMY & CMYK COLOUR MODEL

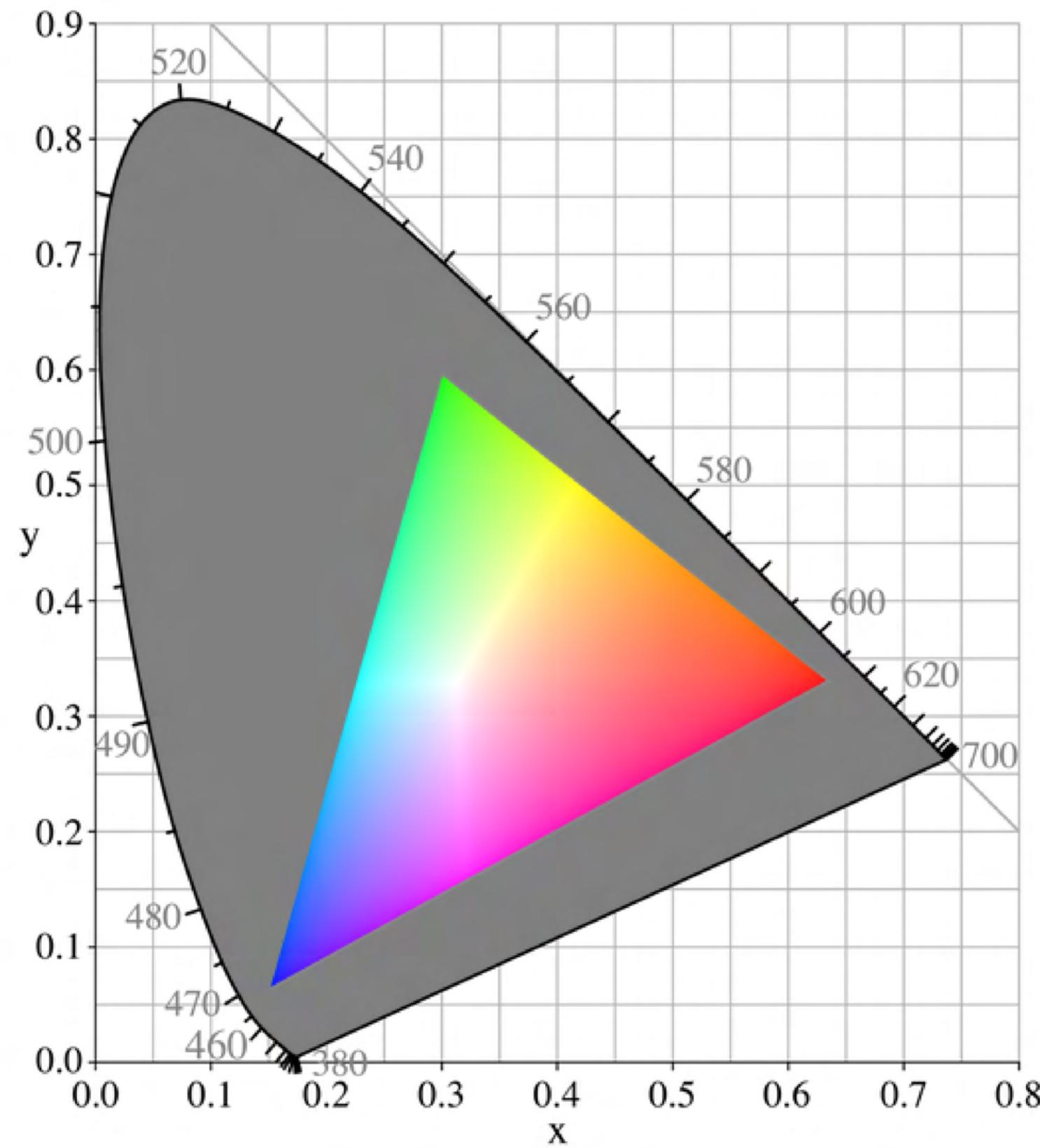
The CMY model doesn't actually include black, like CMYK does. The blending of the three colours does create a black (which is visible in this representation of CMY, right). This black isn't as dark as many would like, so CMYK was born to include that extra element.

Like other models, CMYK values are relative to the percentage of each ink in a particular colour. There are still colour spaces and profiles within CMY and CMYK.



LIST OF (MANY) ADDITIONAL COLOUR SPACES

- AMS595A
- BS
- CcMmYK
- Coloroid
- DCI-P3
- iCAM
- HCL
- heptatone
- hexachrome
- HSI
- HKS
- HVC
- HWB
- LMS
- LCh
- Luv
- Munsell
- NCS
- NTSC
- opRGB
- OSA-UCS
- PAL
- PCCS
- PMS
- RAL
- REC-2100
- RIMM
- ROMM RGB
- RGK
- RYB
- scRGB
- TSL
- UVW
- YIQ
- YJK
- YUV
- Yxy
- YPbPr



CIE CHROMATICITY DIAGRAM

This is a diagram developed by the CIE (remember them from the colour space earlier?) to represent the entire visible range of colour in two dimensions.

The smaller triangle within that is a representation of the sRGB colour profile range. This chart can be used to represent a colour profile or a device capability.

HOW DO WE PREPARE TO PRINT IF CMYK ISN'T ENOUGH INFORMATION?

WHAT SETTINGS SHOULD WE CHOOSE?

PRINTING

Most commercial printers these days have more than four colours, and they utilize all of them to create the colours we use.

It decides on colours by reading the image and the colour profile we set within that image. Since the conversion between 8x3 bit RGB and 8x4 bit CMYK is so challenging, it often makes changes to the colours when that happens.

If we're translating to CMYK, a four-colour model, and then it's translating that to CcMmYK or something even more complicated, it can be difficult to get accurate colours.

By setting things as CMYK, the printer may assume we are telling it exactly what to do, and this can limit its ability to make changes based on its unique technology.

SO, WHAT DO WE DO?

THESE ARE THE TWO MOST IMPORTANT THINGS. THERE ARE MORE.

SPEAK THE PRINTERS LANGUAGE

The printer we use for large posters is an HP Designjet T930. It reads Adobe PDF (1.7 or older), TIFF, JPG, PS, and various technical files. The colour profile it works best with is Adobe RGB 1998; it has the technology to translate this to its six-ink system effectively. There was no specific colour profile built for this printer.

For you? Ask your printer for an accurate colour profile. If they don't understand, ask for information about the printer. Googling any printer model will tell you more about the colour model it uses.

SOFT PROOF BEFORE PRINTING

Open the file in Adobe Acrobat Pro. Using the *print production* tool open *Output preview*. Select *simulate overprinting* and *simulate paper colour*. Remember to turn your screen brightness down to ensure you get a more accurate image.

To see ink coverage and check for dark spots, use simulation profile *Agfa: Swop Standard*. The image itself won't be exact, but you can now spot-check the ink coverage in darker areas. More on that shortly.

Get GEARED UP to Celebrate!

Your once in a lifetime achievement with us.

| | |
|--------------------------|-------------------|
| Russell Athletic Hoodie* | \$74.99 |
| Program-specific Hoodie | \$64.99 |
| | |
| Hat | \$37.99 - \$39.99 |
| Socks | \$20.99 |
| | |
| Mug | \$17.99 - \$34.99 |
| Bottle | \$34.99 |
| Shot Glass | \$11.99 |
| | |
| Graduation Bear | \$35.99 - \$36.99 |
| Cardholder & Pen Set | \$49.99 |
| Pen | \$7.99 |
| | |
| Keychain | \$7.99 |
| Reusable Bag | \$2.00 |

*plus applicable taxes

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no colour
management

Get GEARED UP to Celebrate!

Your once in a lifetime achievement with us.

| | |
|--------------------------|-------------------|
| Russell Athletic Hoodie* | \$74.99 |
| Program-specific Hoodie | \$64.99 |
| | |
| Hat | \$37.99 - \$39.99 |
| Socks | \$20.99 |
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*plus applicable taxes

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LOOKING CLOSER AT CMYK

The image shows a woman smiling, wearing a white graduation cap. To the left of the image is a screenshot of the Photoshop Output Preview dialog. The dialog shows various price ranges and a breakdown of ink coverage.

Output Preview

Simulate

- Simulation Profile: Photoshop 4 Default CMYK
- Simulate Overprinting
- Page has Overprint: No
- Simulate Paper Color
- Set Page Background Color
- Simulate Black Ink
- Ink Manager

Show

- Show: All
- Warning Opacity: 100%
- Show art, trim, & bleed boxes
- Set Page Boxes

Preview: Separations

Separations

| Name | |
|---------------------|------|
| Process Plates | |
| Process Cyan | 34% |
| Process Magenta | 72% |
| Process Yellow | 75% |
| Process Black | 63% |
| Total Area Coverage | 244% |

Sample Size: Point Sample

Total Area Coverage 280 %

Page has Transparency: Yes

Transparency Blending Color Space: DeviceRGB

what you're looking for?
[icis.ca](#) for more selections and styles.

\$17.99 - \$34.99
\$34.99
\$11.99

\$35.99 - \$36.99
\$49.99
\$7.99

\$7.99
\$2.00

If we want to control our colours better with the HP printer and avoid dark images we need to consider ink saturation. As colours blend, they create black. If you have more than ~50% black in a blend or more than 200% ink coverage in total, it will show as black. If this is happening, you'll need to update the image to lighten it or reduce "overprinting."

In this image, we can see CMYK is going to use 244% ink coverage on the brightest part of the neck (63% black) which translates to a rich black. You can see this in both printed images. This is why changing the colour profile alone isn't enough; we need to soft-proof the file.

WHAT ELSE IS GOING ON IN THAT CASE STUDY?

IT'S A DARK PRINTER

This printer is made for architectural drawings; it has three shades of black! As a result, it tends to print darker/duller images than the Versant 180 (our toner-based printer) does.

WE DON'T USE A RIP

We have an amazing pre-press system, FIERY by EPI, and we use that on our main printers. It considers paper porosity, colour coverage, and more. It integrates AI to make decisions. Unfortunately, it isn't used on all printers, and this process is often manual.

NOT FOR PHOTOS

This printer is made for accuracy in *line*, not in *colour*. We need to adapt to make it work for us, and we need to ensure we're managing our colours much better.

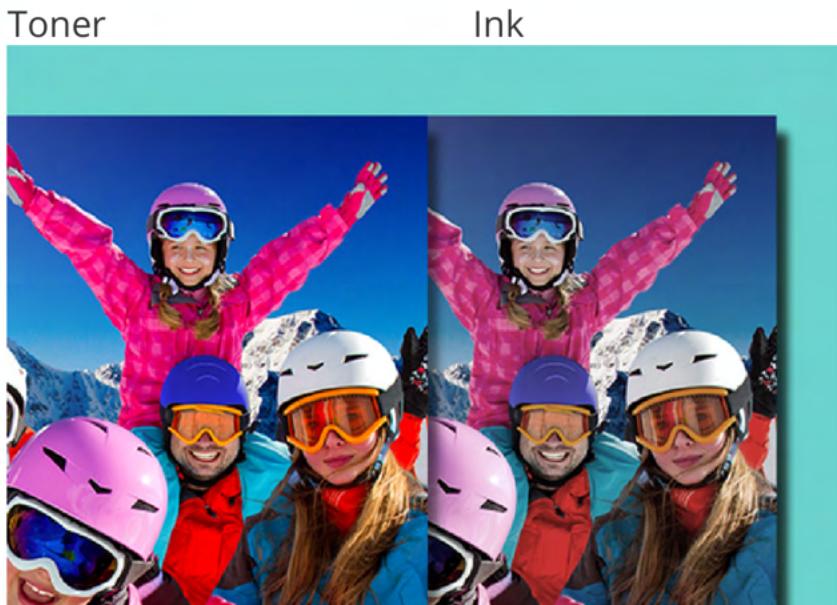
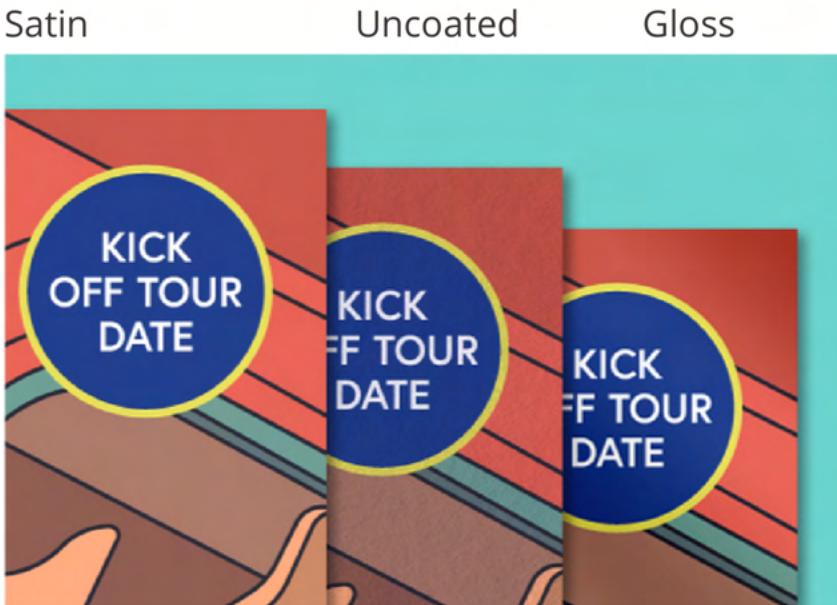
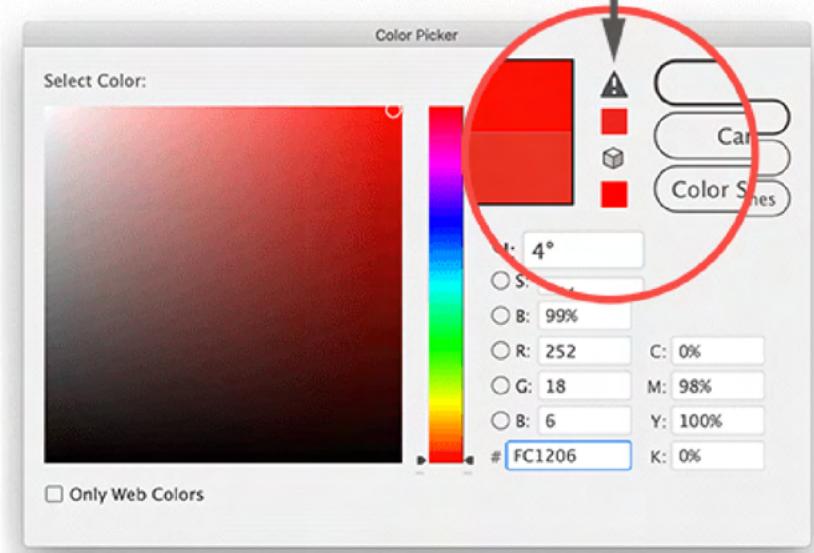
FINAL THOUGHTS

FILE TYPES

There is a more accurate-to-colour file type around, but it is old. PS, or postscript. This printer is made to read PS language, and we could use that format to send to print easily.

HISTOGRAM

A histogram is a graph that measures the brightness of an image by representing the frequency of each tone as a value on a bar chart. This tool can help us decide if an image needs editing before we get to the final stages.



OUT OF GAMUT

InDesign, Photoshop, and Illustrator have a warning system if you use a colour that will be inaccurate; watch for this exclamation mark.

PAPER TYPE

Different papers absorb inks and reflect light differently. They also have slightly different shades of white. All of these factors will affect how the final image looks.

TONER VS. INK

Toners bind dry pigment (through electrostatic charge) to paper. Because of this, the colours are much brighter than liquid inks which dry on the page.

SOME PRINTERS DO COLOUR BETTER:



**EPSON
SURECOLOR P9570**

\$9k MSRP, 44"

12-Colour Printing



**CANON
IMAGEPROGRAF GP-4000**

\$9k MSRP, 44"

10-Colour Printing

QUESTIONS



WHAT NEXT?

TRY A COLOUR TEST

Search “Farnsworth 100 hue test” and try it.

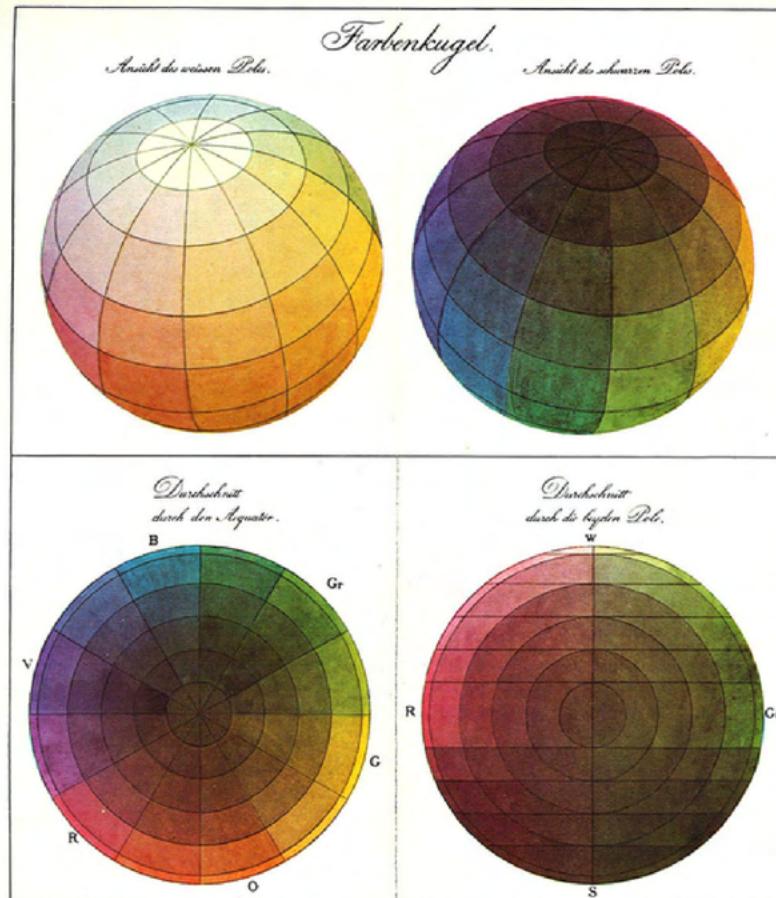
CHECK OUT THIS RESOURCE

gamutmap.com

A BRIEF HISTORY OF COLOUR

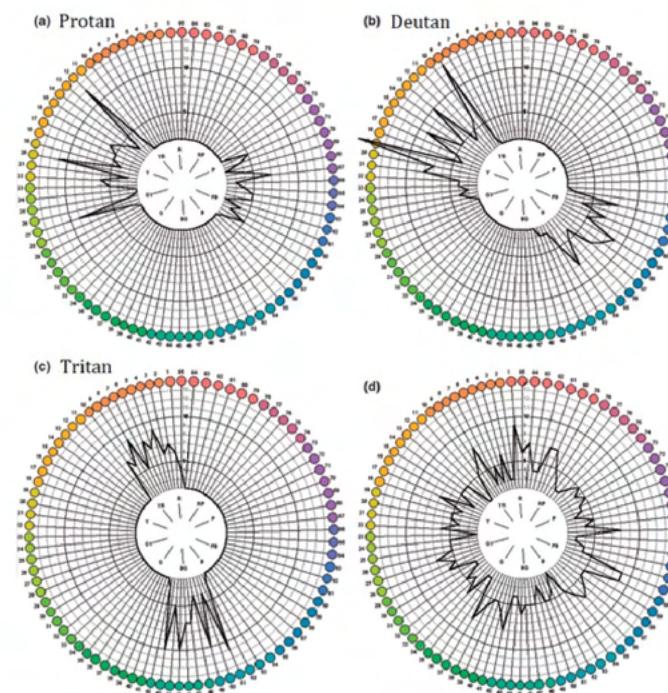
1810: PHILIPP OTTO RUNGE'S COLOUR SPHERE

While this colour sphere was mathematically imperfect, it was one early example of mapping colour into three-dimensional space.



1905: THE MUNSELL COLOR SYSTEM

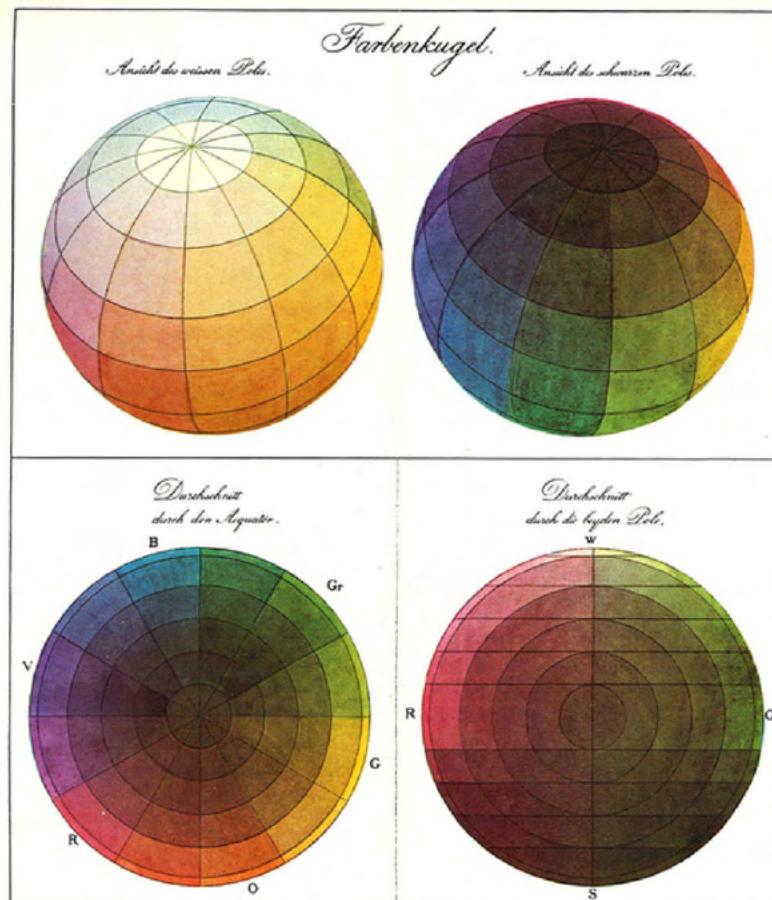
Argued that the concept of lightness was a separate attribute to that of color; he published his colour system first in *A Color Notation*, and published a revised system in 1929 in the *Munsell Book of Color*.



A BRIEF HISTORY OF COLOUR PROFILES

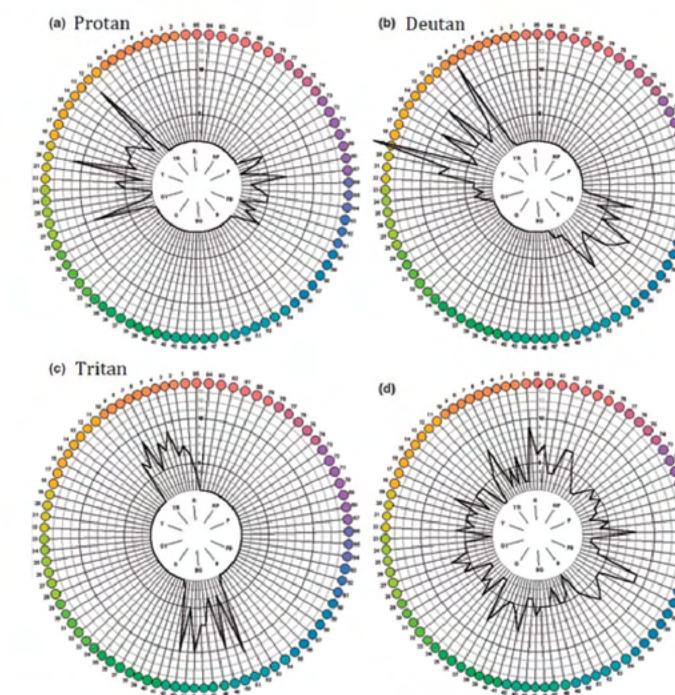
1810: PHILIPP OTTO RUNGE'S COLOUR SPHERE

While this colour sphere was mathematically imperfect, it was one early example of mapping colour into three-dimensional space.



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Argued that the concept of lightness was a separate attribute to that of color; he published his colour system first in *A Color Notation*, and published a revised system in 1929 in the *Munsell Book of Color*.



Q.

Discussing a lesson as a class certainly boosts students' interest and engagement. Aside from helping them stay focused, it allows them to think deeply, create connections, and get different perspectives on the subject matter.

TERMS TO REMEMBER

GAMUT

Limitations...

LIGHTING

impact on final product... why
printers have light booths,
colour temperature,
reflection, metamerism, etc.

CONVERSIONS

Write the question you want
to ask your students and allot
space for the answers.

INK

ink responds to surfaces in a
physical way that's not always
reproducible visually

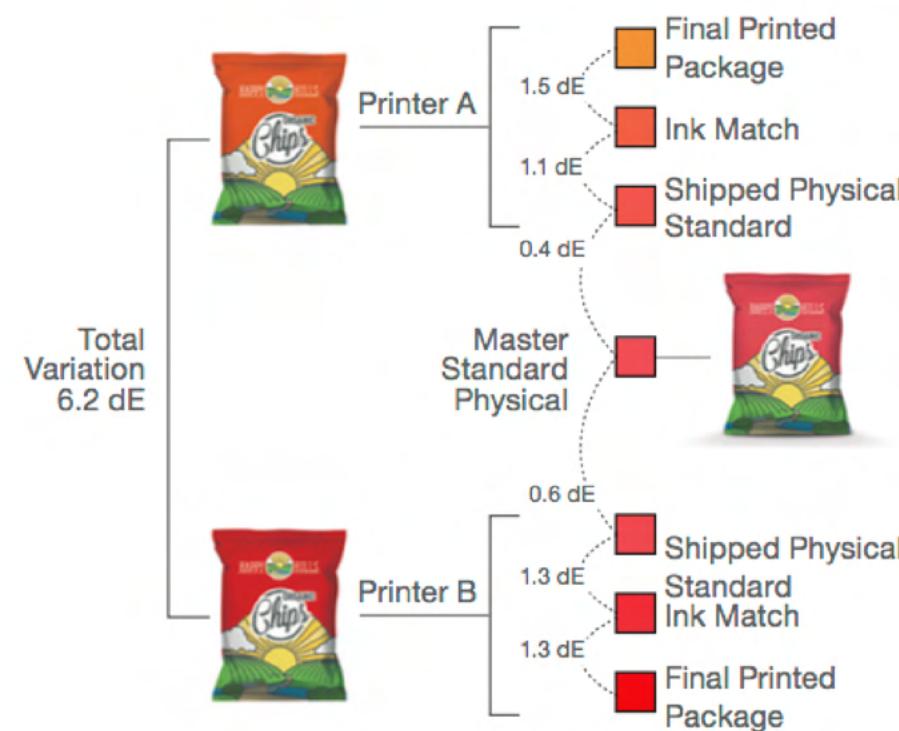
HEX IS RGB

CEI, ICC, GCR, UCR

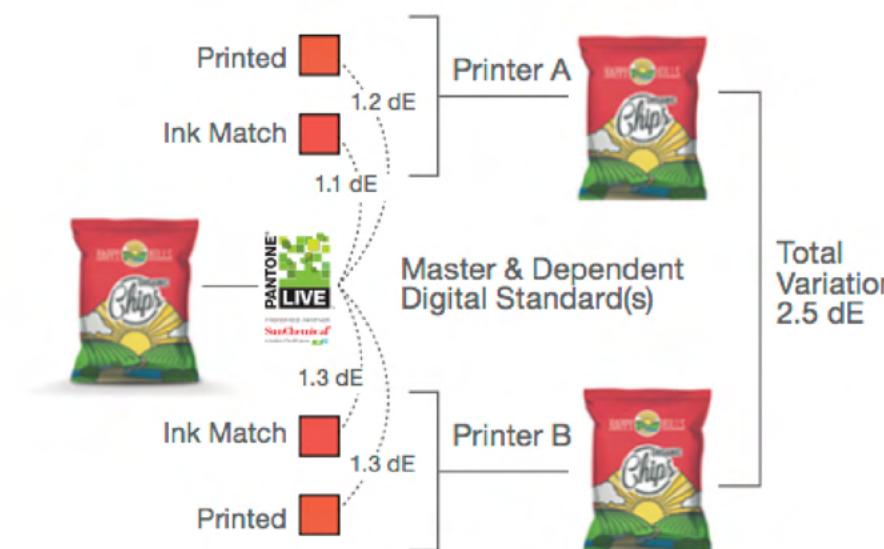
MEASURING COLOUR: PHOTO...?

how often do you print a colour, and it's far from what you expected? look at equipment for this

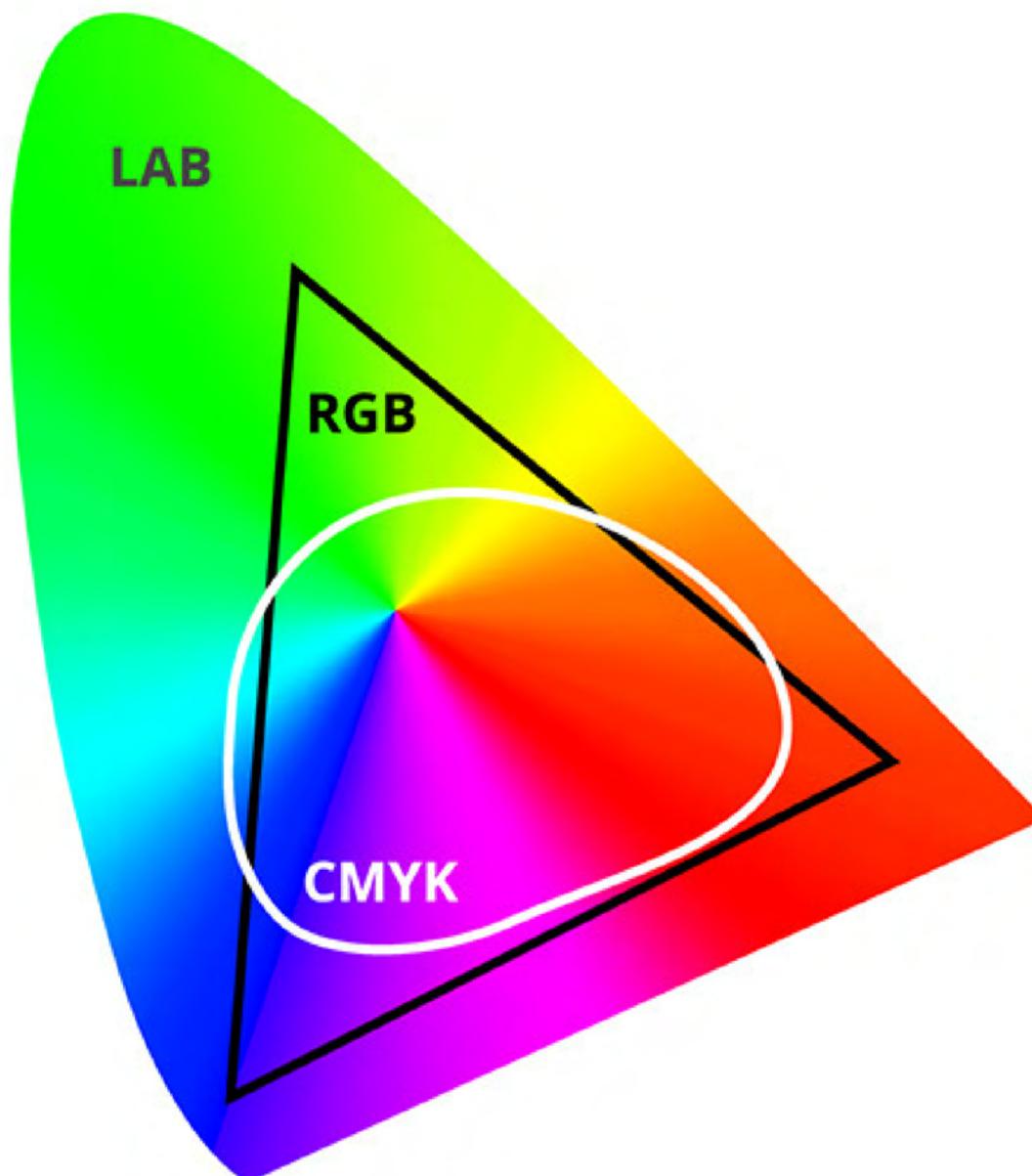
The Error Stack Comparison



Reducing The Error Stack



OTHER FACTORS



GAMUT

PAPER AS A MEDIUM

Screens are backlit, paper is not.

INK AS A MEDIUM

Hmm

HEX CODES

Hmm

CONVERSIONS

Hmm

ICC, GCR, UCR

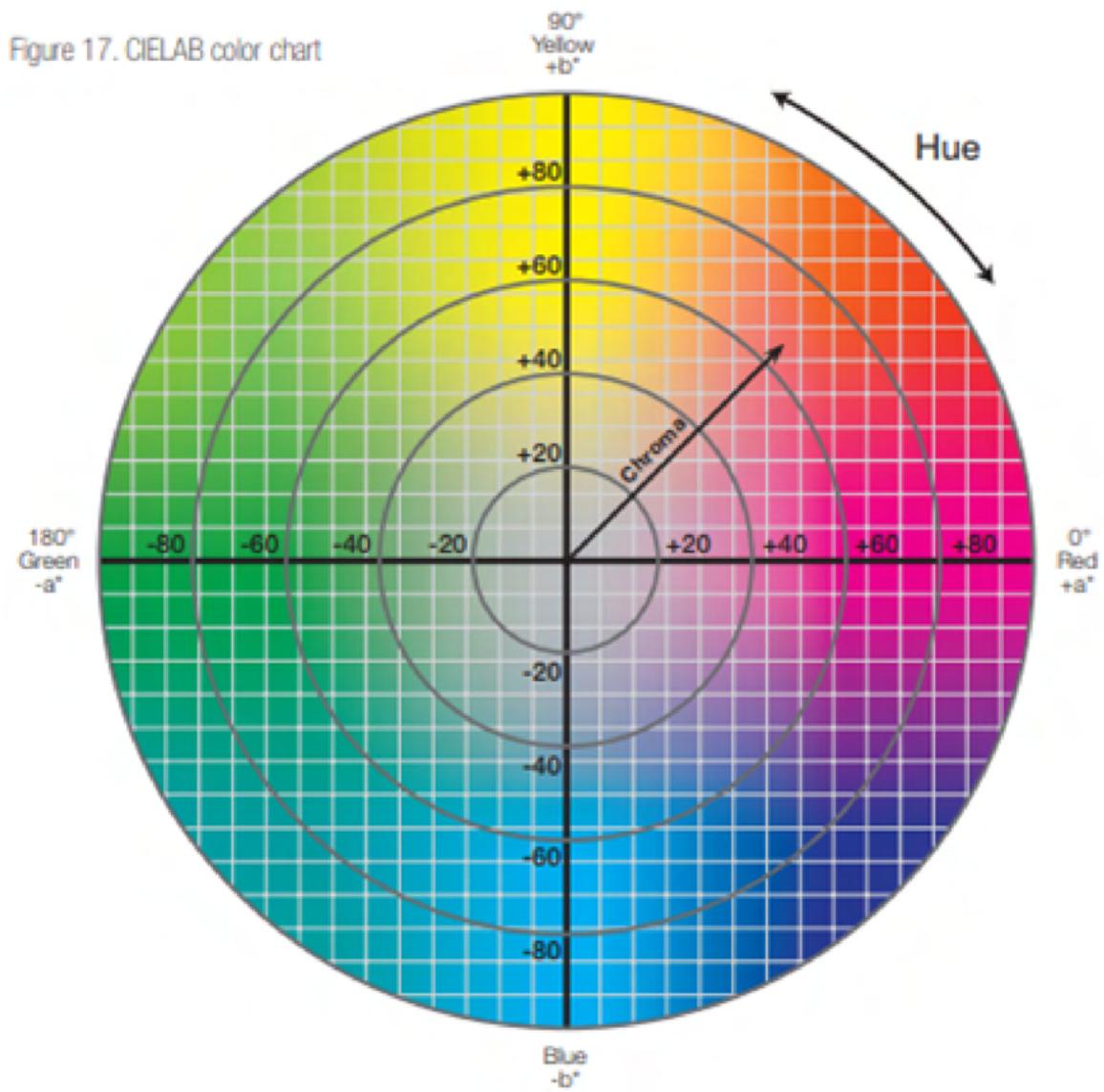
Hmm

ORGANIZATIONS

Hmm

COLOUR PROFILES

Figure 17. CIELAB color chart



AdobeRGB 1998

SWOP

?

CLUT:

A CLUT is essentially a table that contains a list of color values, and each value corresponds to a specific input color.

| |
|--------------------------------|
| + Basis Weight (lbs) |
| + M Weight (lbs/1000) |
| + Caliper Range |
| + Approx. Caliper |
| + Grammage (g/m ²) |
| + Size (in x in) |
| + Finish |
| + Coating |
| + Smoothness |
| + Colour |
| + Brightness |
| + Recycled Content |
| + Sheets per Package |
| + Sheets per Case |

- » Uncoated Folio
- » Uncoated Cut & Digital
- » Coated Folio
- » Coated Cut & Digital
- » Writing, Text & Cover Folio
- » Writing, Text & Cover Cut & Digital
- » Synthetic Folio
- » Synthetic Cut & Digital
- » Carbonless Folio
- » Carbonless Cut & Digital
- » Pressure Sensitive Folio
- » Pressure Sensitive Cut & Digital
- » Copy & Colour Copy Cut & Digital

| BOND | TEXT | COVER | INDEX | MM | GSM |
|-------|-------|-------|-------|-------|--------|
| 2.7lb | 6.7lb | 3.7lb | 5.6lb | 0.004 | 10 |
| 14lb | 36lb | 20lb | 30lb | 0.075 | 55 |
| 16lb | 40lb | 22lb | 33lb | 0.081 | 60.2 |
| 17lb | 43lb | 24lb | 36lb | 0.087 | 67 |
| 18lb | 45lb | 25lb | 37lb | 0.092 | 67.72 |
| 20lb | 50lb | 28lb | 42lb | 0.097 | 75.2 |
| 24lb | 60lb | 33lb | 50lb | 0.12 | 90.3 |
| 28lb | 70lb | 39lb | 58lb | 0.147 | 105.35 |
| 29lb | 73lb | 40lb | 60lb | 0.152 | 109.11 |
| 32lb | 80lb | 46lb | 67lb | 0.156 | 119 |
| 36lb | 90lb | 50lb | 75lb | 0.173 | 135.45 |
| 39lb | 100lb | 54lb | 81lb | 0.183 | 146.73 |
| 40lb | 100lb | 56lb | 83lb | 0.185 | 150.5 |
| 43lb | 110lb | 60lb | 90lb | 0.188 | 161.78 |
| 44lb | 110lb | 61lb | 92lb | 0.193 | 165.55 |
| 47lb | 120lb | 65lb | 97lb | 0.198 | 176.83 |
| 53lb | 135lb | 74lb | 110lb | 0.216 | 199.41 |
| 58lb | 146lb | 80lb | 120lb | 0.234 | 218.22 |
| 65lb | 165lb | 90lb | 135lb | 0.241 | 244.56 |
| 67lb | 170lb | 93lb | 140lb | 0.25 | 252.08 |
| 72lb | 183lb | 100lb | 150lb | 0.289 | 270.9 |
| 76lb | 192lb | 105lb | 158lb | 0.33 | 285.95 |
| 79lb | 201lb | 110lb | 165lb | 0.34 | 298 |
| 82lb | 208lb | 114lb | 170lb | 0.356 | 308.52 |
| 87lb | 220lb | 120lb | 180lb | 0.38 | 312 |
| 105lb | 267lb | 146lb | 220lb | 0.445 | 385.06 |

10 gsm



35 gsm



17lb bond



20lb bond



24lb-32lb bond



60lb-80lb text



80lb-100lb text



60lb-120lb cover



