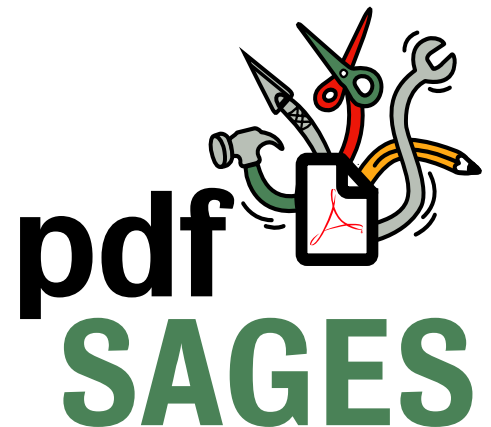


Color Management & PDF

Leonard Rosenthol
Chief Technology Officer
PDF Sages, Inc.



Where are the slides?

■ <http://www.pdfsages.com/downloads/ColorManagement.pdf>

- Sorry about no printouts, but you've probably already heard that I am NOT happy with Kinkos from the last two days and wasn't giving them any more \$\$ to screw things up!

Overview

- Who are you? What do you already know?
- A bit about “color by numbers”
- Goals & Objectives of Color Management
- History of Color Management
- Steps in Color Management
- Color in PDFs
 - Color and Acrobat
 - 3rd party solutions & tools

Survey time...

- How many have some idea what “color management” is?
- How many immediately turn that option off in your Adobe apps?
- How many think “ICC” is what you say when you get RGB data from your customers?



Goals Of Color Management

- To provide consistent and accurate display of color among multiple input, display and output devices
- Minimize the perceived differences in displayed colors between devices

Why is Color Management Necessary?

- The different devices have different gamuts or ranges of colors that it is capable of reproducing
- Every input, display and output device has a specific range of colors, determined by the physical and chemical properties of the medium
- [DEMO ColorThink]

Other reasons CM is necessary

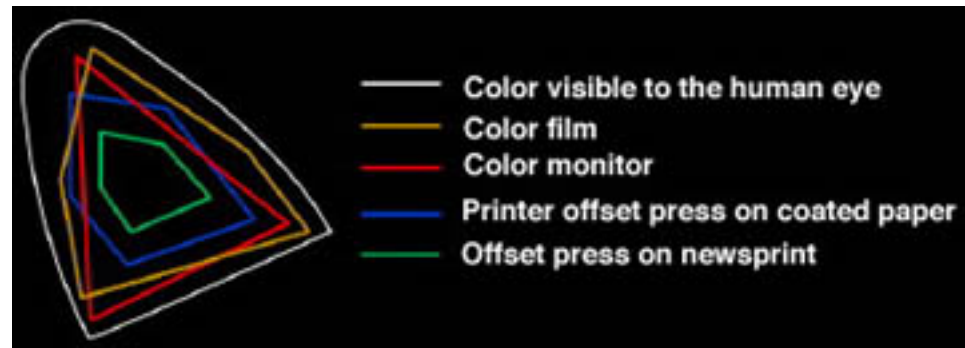
- Device-dependent colors don't match from device to device
 - Toaster theory of Colors
 - ◆ Or why CMYK isn't G-d's gift to designers...



WYS

is not

WYG



■ Cameras:

- Different image capturing technologies

■ Scanners:

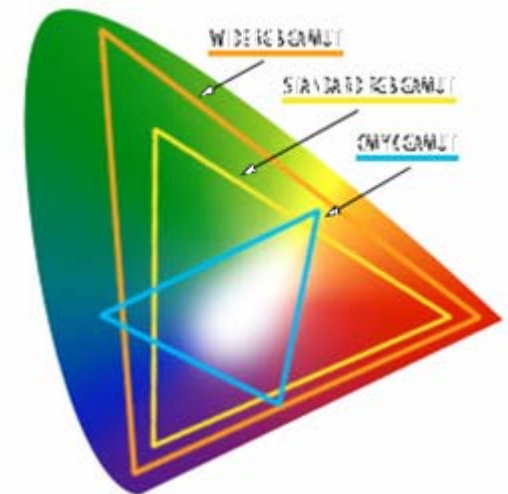
- Light source, optical path, sensor, electronics, firmware and software, media (reflective or transparent)

■ Monitors

- Types of CRT's, tolerances in phosphors, different video boards, ambient lighting conditions, aging of CRT

■ Printers

- Different color processes, different imaging technologies, different inks, toners, paper, different device drivers



History of the International Color Consortium (ICC)

- Prior to 1995, every vendor used proprietary format for device profiles
- Committee formed in April, 1993 as the ColorSync Consortium led by Apple Computer
- Founders consisted of the print research association and major manufacturers of color graphic hardware & software

Objectives of the International Color Consortium (ICC)

- Goal: to develop an open vendor-neutral, cross-platform color management system architecture
- Based on the assumption that each device could be profiled to describe the transformation from the device's color space to a reference space
 - (Profile Connection Space or PCS)
- Today every major manufacturer uses ICC-standard profiles
 - But Microsoft wants to change that with Longhorn ☹

Software Level of CM Implementation

■ System Level

- Macintosh – ColorSync
 - Every object drawn on your screen is color managed
 - Every object written to PDF has an attached profile
- Windows - Image Color Management (ICM)
 - » (Windows '98 and later)

■ Application Level

- Commercial applications:
 - Adobe Creative Suite
 - Corel Photo-paint & CoralDRAW
 - Macromedia Freehand
 - Quark Express
- Open Source
 - CinePaint
 - Scribus

Color Management Objectives

■ Input Driven

- Color encoding represents colors of the input images and colors produced by the output match the input as best possible
 - Example: color copiers

■ Encoding Driven

- The encoding is based on a unified color-encoding concept that eliminates differences inherent in system inputs
 - Example: colors scanned from a transparent medium are altered to resemble values derived from a reflection print

■ Output Driven

- Based on unified encoding, but output colors are rerendered to consider characteristics of the output device
 - Example: rerendered to take advantage of a larger device gamut

Functions of Color Management

- **ENCODE** an image in terms of:
 - 1) the input image colors
 - 2) the original scene colors
 - 3) in terms of a reference device/medium

- **MATCH or MAP Colors**
 - Match colors from input to display to output when colors are within the gamut of all devices used
 - MAP colors outside the gamut of the selected output device to values that can be reproduced

- **OUTPUT** an image that best represents:
 - 1) the input image
 - 2) the encoded image
 - 3) the “best” image that can be reproduced on the given output device

Steps in Color Management

■ Device Calibration

- Accounts for local variation from one instance of a device to another

■ Device Characterization (Profiling)

- Accounts for colorimetric properties of each class of display devices

■ Color Conversion

- Permits the image to be displayed as it was intended on different display devices

Device Calibration

- Establishes a standard state from which a device can be profiled
- Return a device to its normalized state
- Calibrate regularly to keep the profile valid



5 Methods to Calibrate

■ By Estimation

- ColorSync or Adobe Gamma (Photoshop utility)

■ By Estimation with reference

■ Beam Current Auto-Calibration

- new in Apple ColorSync monitors
- color characteristics measured and stored on ROM chip

■ Control through Colorimeter Measurements

- Increased color accuracy because known values are measured in closed loop system

■ Controlling Monitor Brightness

- brightness controlled by calibration system

Device Characterization (Profiling)

- Measure devices to create custom device profiles
- Profiles represent the behavior of a device in the real world
- The profile describes the characteristics of your input, display and output devices
- Information is stored in the CIE Lab color model which acts as a universal translator between different color models

3 Measurement Devices



■ Densitometer

- A photo-electric device that measures & computes how much of a known amount of light is reflected from or transmitted through an object (Primarily used for print)

■ Colorimeter

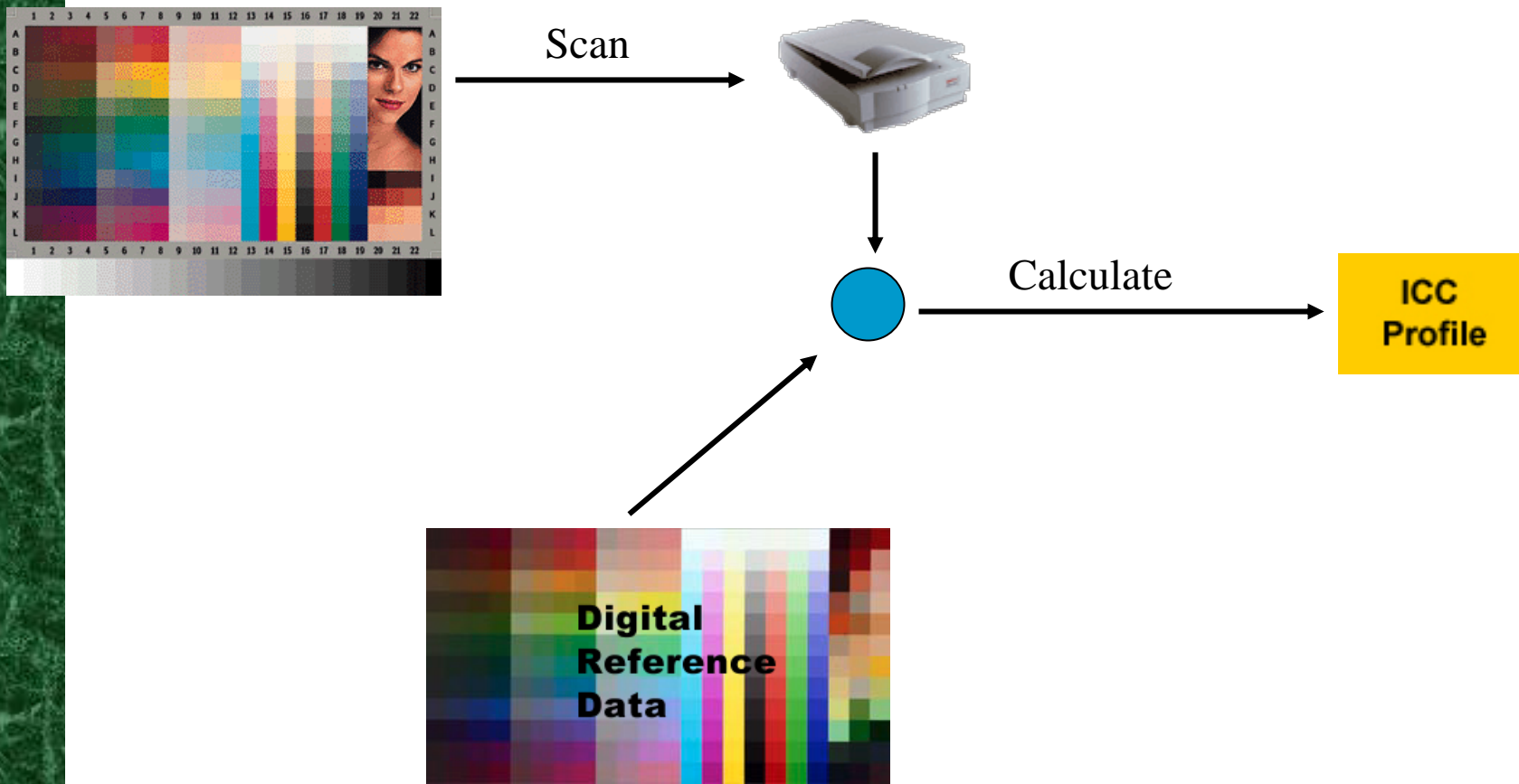
- Measures light, breaking it down into its RGB components in a manner similar to the human eye
- Determines colors numeric values using the CIE color space

Spectrophotometer

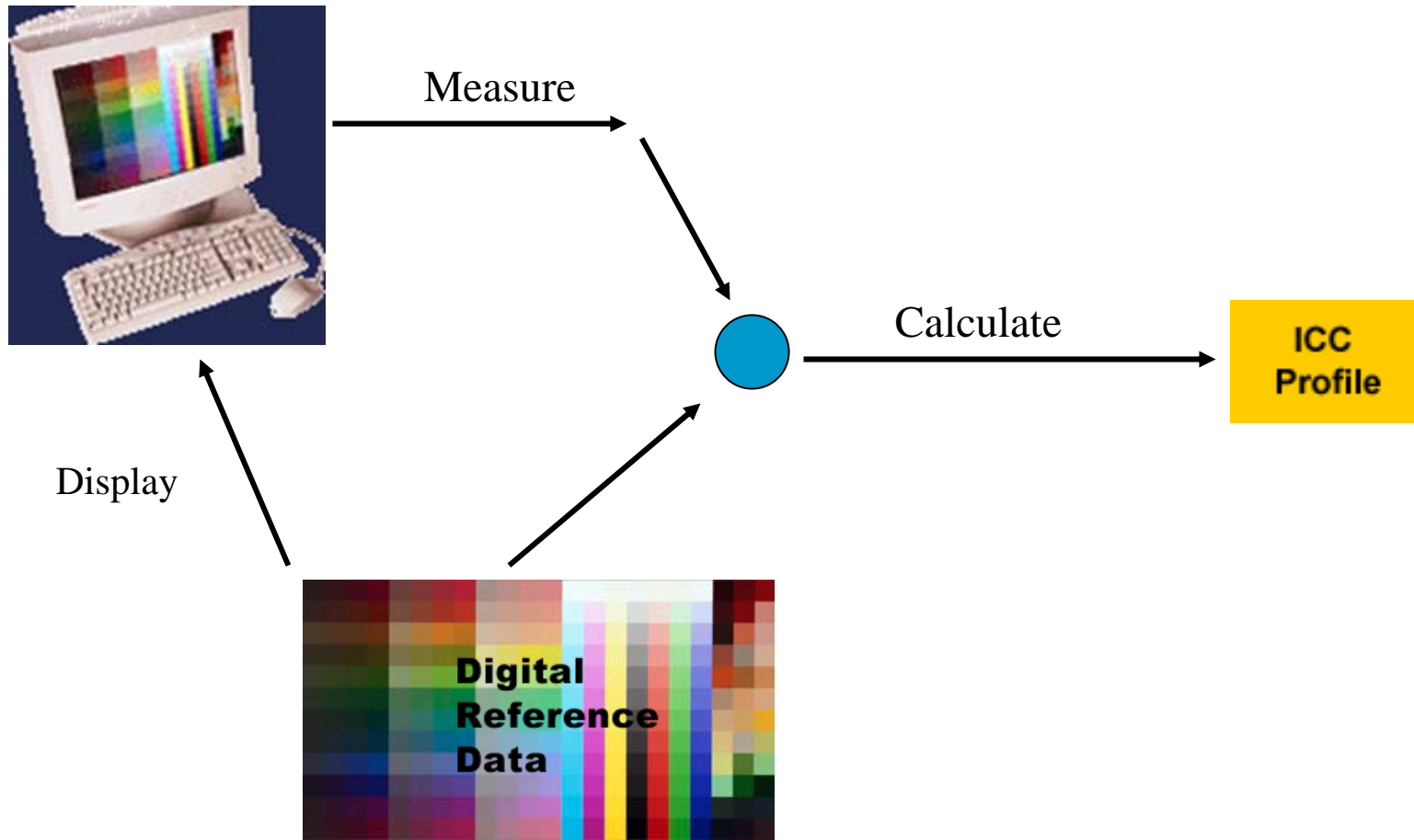
- Measures the amount of light energy reflected from an object at several intervals along the visible spectrum
- Values usually interpreted as a spectral curve
- Most accurate device



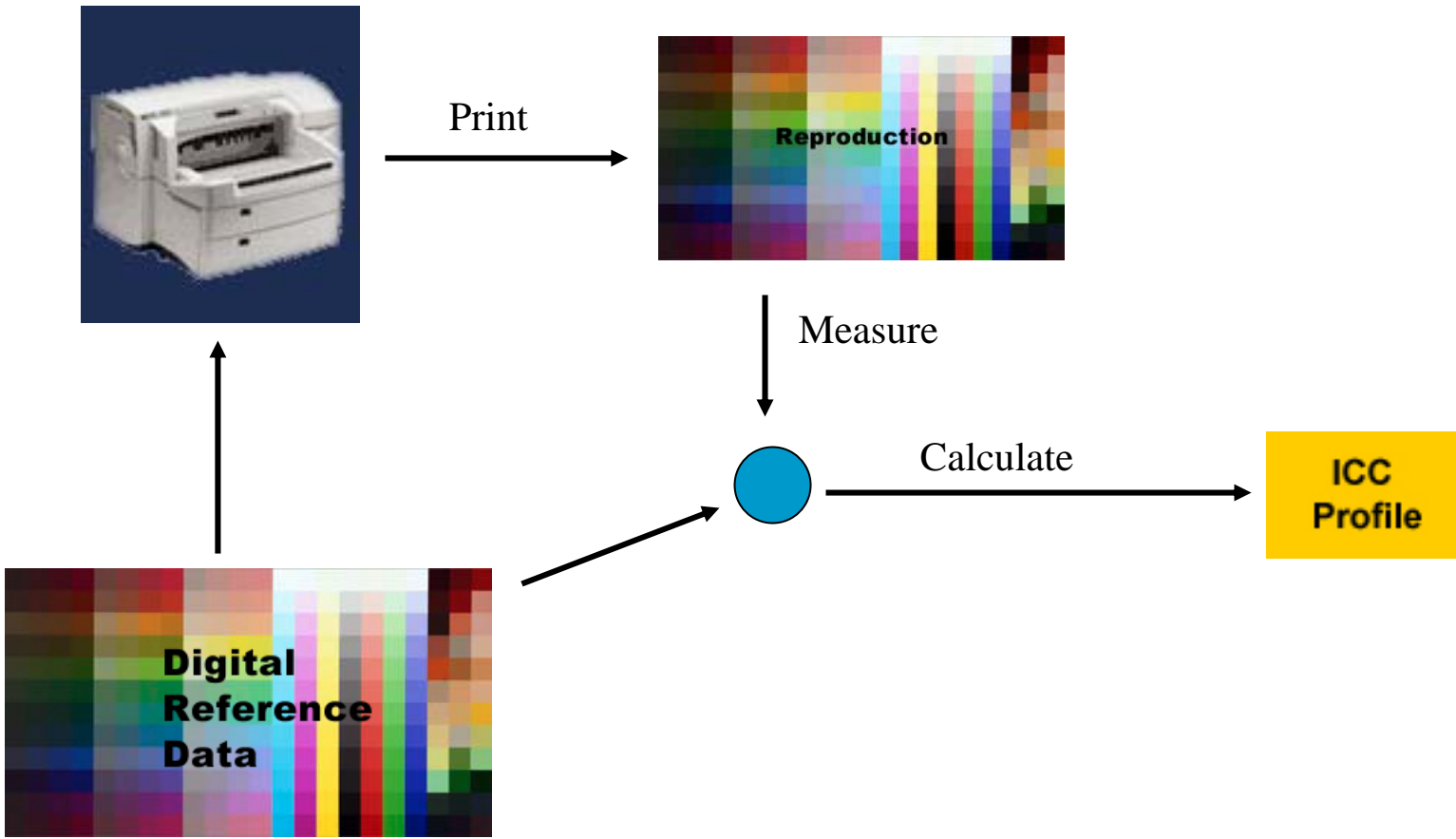
Input Device Characterization



Monitor Device Characterization



Printer Device Characterization



ICC Profiles

- Are interchangeable between application programs, operating systems and computer platforms
- Manufacturers may provide generic profiles that describe a theoretical calibrated device
- For best results, you must create your own custom profiles
- May include manufacturer proprietary information (tags)

Color Conversion Engine -> The Color Management Module

- Transform color values from one color space to another to compensate for the profile of a particular device

- Different conversion engines available:
 - Apple ColorSync
 - Heidelberg's LinoColor Color Transform Engine (CTE)
 - (Used by Microsoft's ICM 2.0)
 - Adobe Color Engine (ACE)
 - Alternative CMM's available from Kodak, Agfa, & Imation

- A manufacturer proprietary color engine can make use of proprietary information stored in the ICC profile

Mapping Colors with “Rendering Intent”

- Defines the method of color mapping to be applied between the source and destination profiles

- Four choices defined by ICC:
 - Perceptual* (photographic) - called picture intent or image
 - Relative Colorimetric (approx. color appearances) - called proof intent
 - Saturation (for business graphics) - called graphic intent or graphics
 - Absolute Colorimetric - called match intent

- *default

Types of ICC Profiles

■ Device Profiles

- Color space of a particular device

■ Abstract Profiles

- Allows applications to perform special color effects independent of the device (make subjective changes)

■ Device Link Profile

- Combines multiple device, abstract and color space profiles
- First and last are usually the source and destination

■ Named Color Profiles

- Siblings of device profiles - for different consumables/vendors

■ Color Space Profiles

- Contains data necessary to translate between different color spaces (CIE <>RGB)

What happens when you don't use ICC profiles?

- Correct – Acrobat 7
- Incorrect – every other PDF viewer ☹
- DEMO

Color Spaces in PDF

- PDF Supports 11 color spaces
 - 3 device dependant
 - ♦ DeviceGray, DeviceRGB & DeviceCMYK
 - 4 device independent
 - ♦ CalGray, CalRGB, Lab & ICCBased
 - 4 special
 - ♦ Indexed, Pattern, Separation & DeviceN
 - NChannel (PDF 1.6) is a backwards compatible extension of DeviceN to enable richer and more accurate handling of color blending with dot gain and mixing hints

PDF/X and the Output Intent

- PDF/X (and PDF/A & PDF/E) requires the presence of an embedded profile or characterization reference for the intended output device.
 - This serves as the SOURCE profile for your data and is used by Acrobat (6+) when rendering your documents.

Working with Color in Acrobat

- Setting up working spaces
- Acrobat 7's new Color Convert feature
 - DemoDocument.pdf
 - BigPreview.pdf
- Printing with color management
- Color Management in Distiller

- 3rd party tools and solutions
 - PitStop
 - PDF Enhancer
 - pdfColorConvert

Shortcomings of ICC Color Management

■ Narrow PCS definition

- 4->3->4 conversion (eg. CMYK->CMYK)
- Each profile maker must make assumptions about the viewing conditions the end user and of the PCS
- Actual viewing conditions may be different from assumptions

■ No CMM specification

- Methods of interpolation are not specified
- Two CMM's with identical input can produce different results

■ No guaranteed interoperability

- Vendors use “Private Tags” to overcome inconsistencies
- Different methods are used for gamut mapping

Useful Web References

International Commission on Illumination (CIE)

<http://www.cie.co.at/cie/>

The International Color Consortium

<http://www.color.org>

Information from Apple on ColorSync and Color Management

<http://www.apple.com/colorsyc/benefits/training/index.html>

Information from Microsoft on Image Color Management (ICM)

<http://www.apple.com/colorsyc/benefits/training/index.html>

Information from Adobe on Photoshop and Color Management

<http://www.adobe.com/support/techguides/photoshop/main.html>

Charles Poynton's Color FAQ site

<http://home.inforamp.net/~poynton>

Stephen Westland's Color Physics FAQ

<http://www.colourware.co.uk/cpfaq.htm>



Wrap Up

- Color is fun...

Questions and Answers

