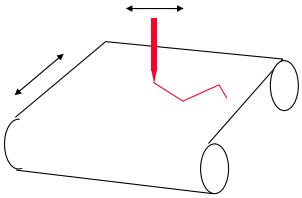
Lecture 10

Printing Devices

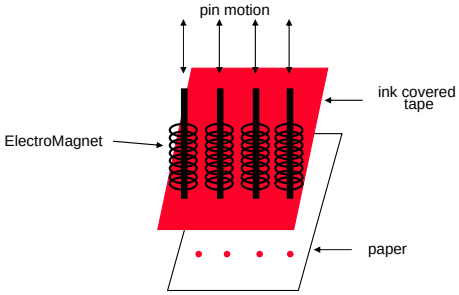
Ink Jet Printers
Laser Printers
Thermal Printers
Dye Sublimation
Halftoning
Dithering
Error Diffusion

Older Printing Devices

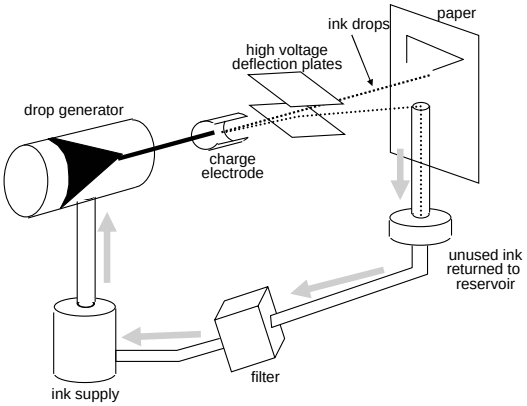
Plotter



Dot Matrix Printer

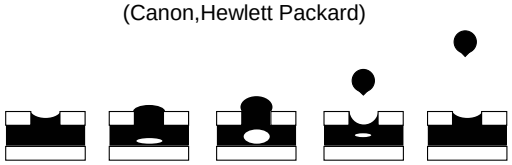


Ink Jet Printer



Thermal-Bubble Ink Jet Printer

(Canon,Hewlett Packard)



Initial State with fluid at rest.

Resistor is heated and bubble nucleates.

Bubble grows to maximum ink drop is ejected.

Bubble collapses. Drop breaks off.

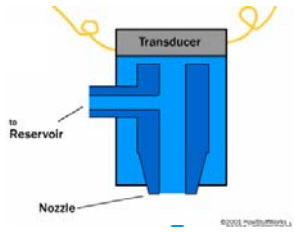
Vacuum created by bubble sucks ink from cartridge.

View of the nozzles in a thermal bubble inkjet.
(some 300-600 nozzles per head)

Demo: http://www.howstuffworks.com/inkjet-printer3.htm

Piezoelectric Inkjet

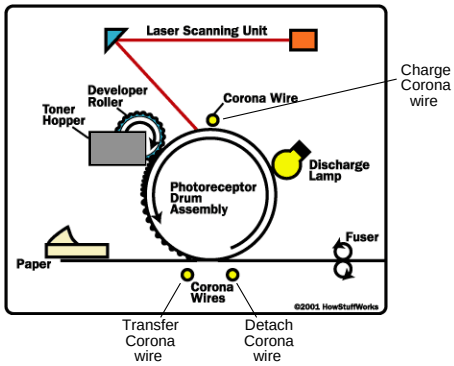
(Epson)



Piezo crystals are located at the back of the ink reservoir of each nozzle. The crystal receives a tiny electric charge that causes it to vibrate. When the crystal vibrates inward, it forces a tiny amount of ink out of the nozzle. When it vibrates out, it pulls some more ink into the reservoir to replace the ink sprayed out.

Demo: http://www.howstuffworks.com/inkjet-printer3.htm

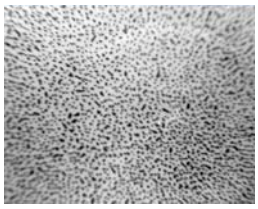
Laser Printer



- Charge corona wire – gives drum initial positive charge.
- Laser "draws" the image to be printed as a pattern of electrical charges -- an **electrostatic image**. Image is negatively charged.
- Positively charged toner clings to drum.
- Toner is deposited on paper (via Transfer wire = charged roller).
- Paper is discharged (via Detach wire)
- Toner is fused into paper with heated fuser.

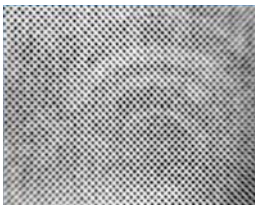
Dot Pattern of Ink Jet and Laser

Ink Printing



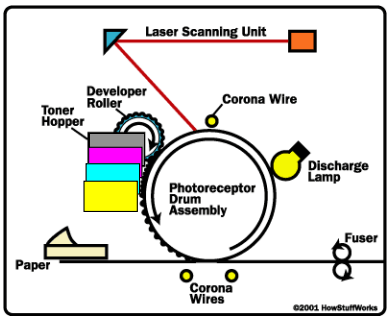
Liquid ink drops are shot onto paper

Laser Printing



Solid particles are attracted to specific points on paper.

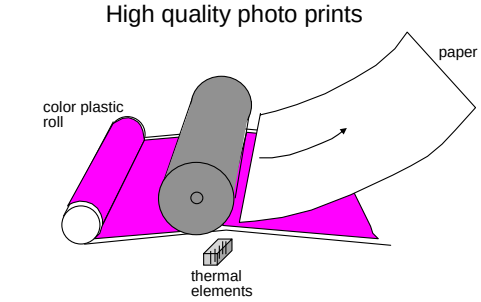
Color Laser Printer

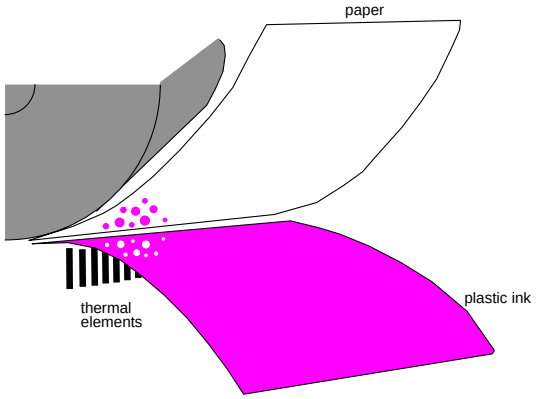


4 x toner and developer mechanisms.
Drum rotates x4 for a single print.

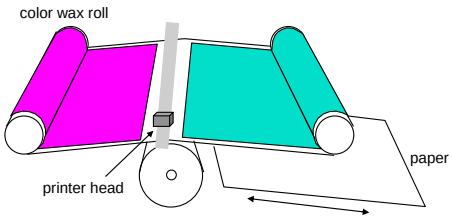
Dye Sublimation Printer

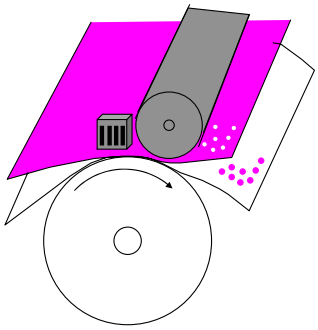
High quality photo prints





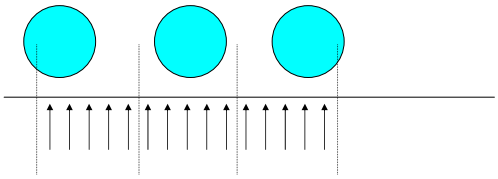
Thermal Wax Printer





Resolution Measures
dots per inch and addressability

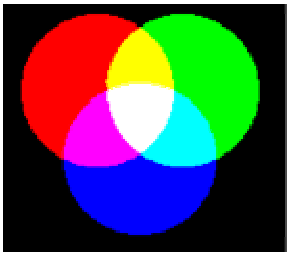
Dots per inch (600)



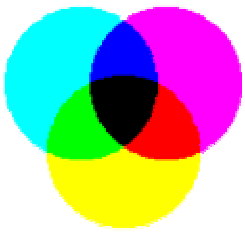
Addressable (3000)

Lights vs Inks
Additive vs subtractive

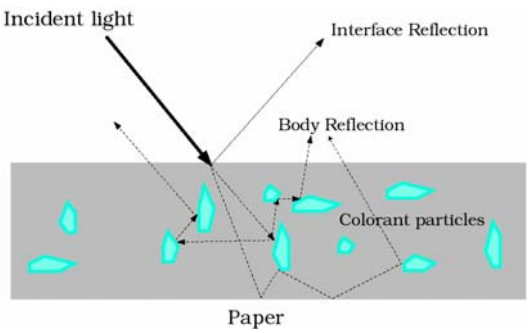
Additive



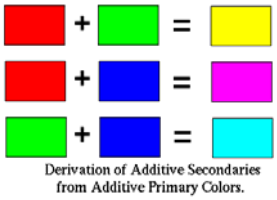
Subtractive



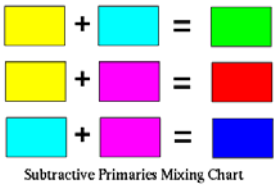
Reflectance Concepts



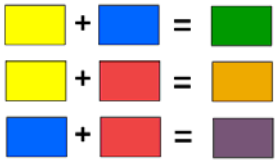
Color Mixtures



Derivation of Additive Secondaries from Additive Primary Colors.



Subtractive Primaries Mixing Chart

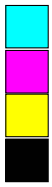


Painting Primaries Mixing chart

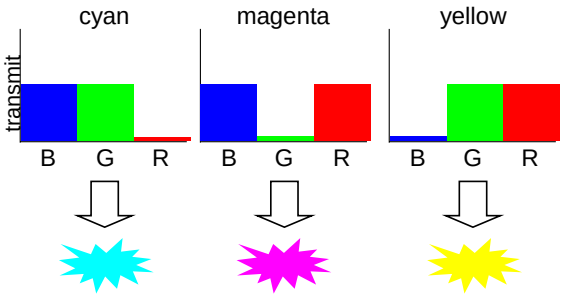
Subtractive Color System - CMYK

Printer Dyes:

cyan	= removes red
magenta	= removes green
yellow	= removes blue
black	= removes all

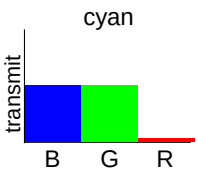


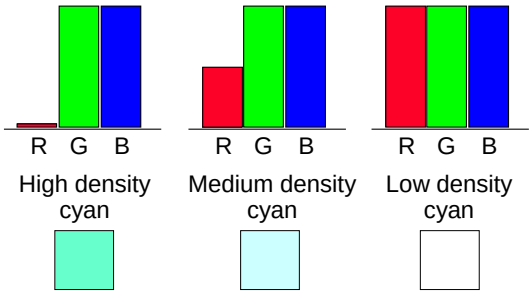
Ideal block dyes:



Cyan - controls amount of red in print:

low C = high R (also high G and B)
high C = low R (high G and B)

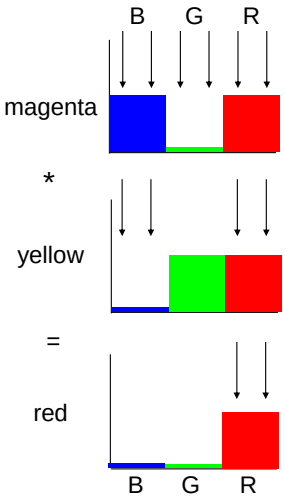




Similarly Magenta - controls amount of green and Yellow – controls amount of blue.

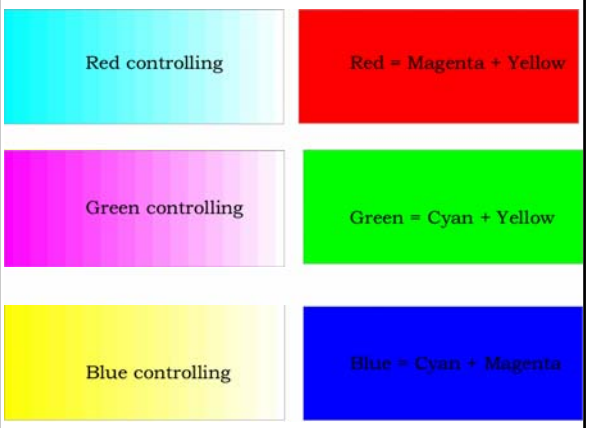
Multiplicative (Subtractive) Color System

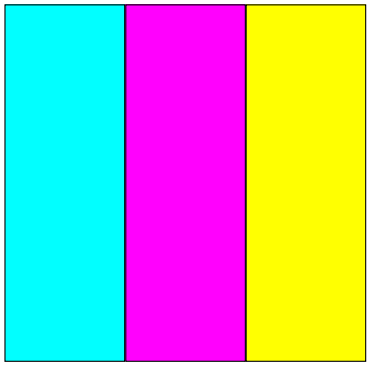
red = magenta + yellow

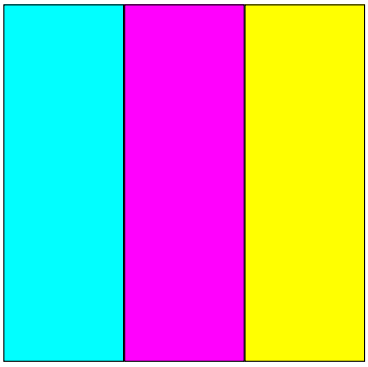


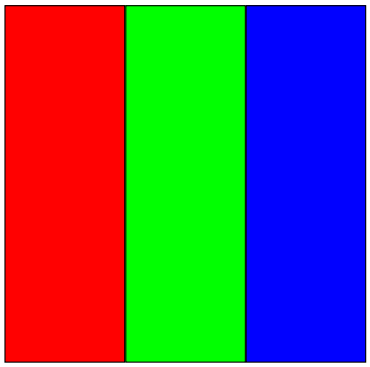
red = magenta + yellow
green = cyan + yellow
blue = magenta + cyan

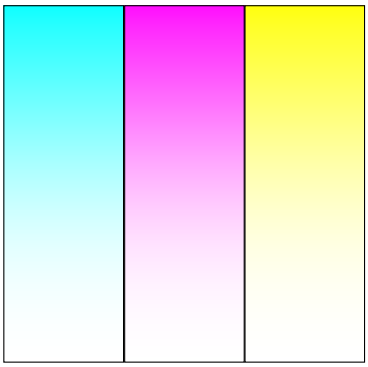
Subtractive Colors - Summary





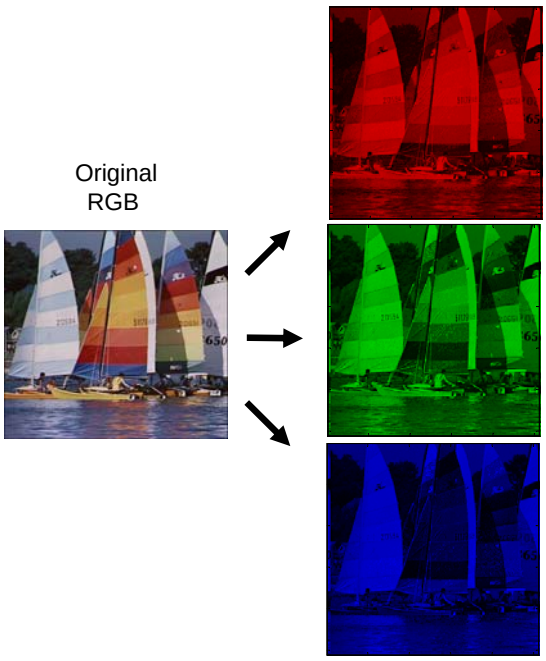






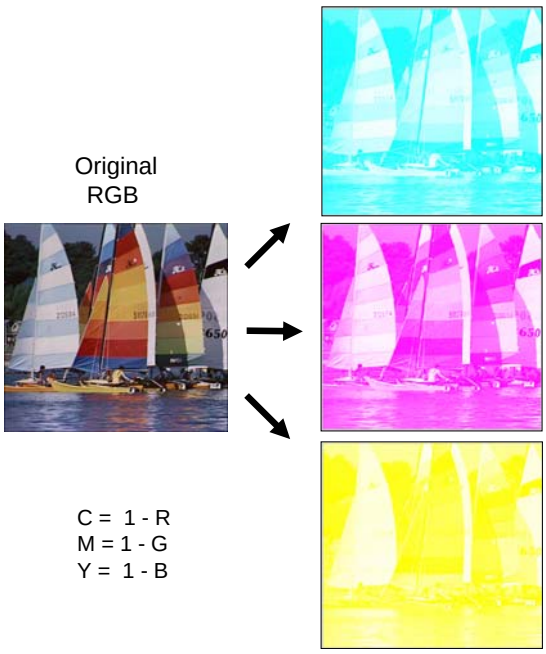
Color Separations
RGB Color Bands

Original
RGB



Color Separations
CMY Color Bands

Original
RGB

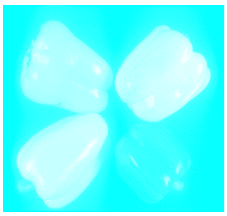


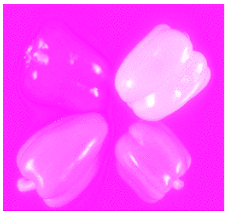
C = 1 - R
M = 1 - G
Y = 1 - B

Color Separations

CMY Color Bands

Original
RGB





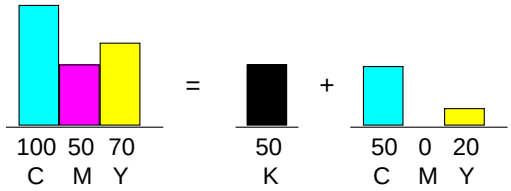
C = 1 - R
M = 1 - G
Y = 1 - B

Undercolor Removal

(gray component replacement)

C + M + Y = K (black)

- Using three inks for black is expensive
- C+M+Y = dark brown not black
- Black instead of C+M+Y is crisper with more contrast.

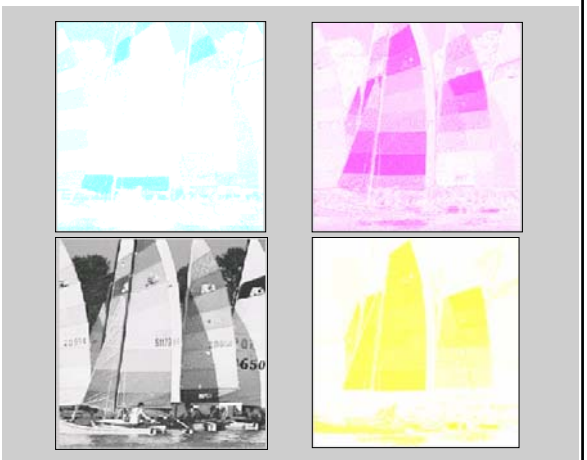


Gray Component Removal

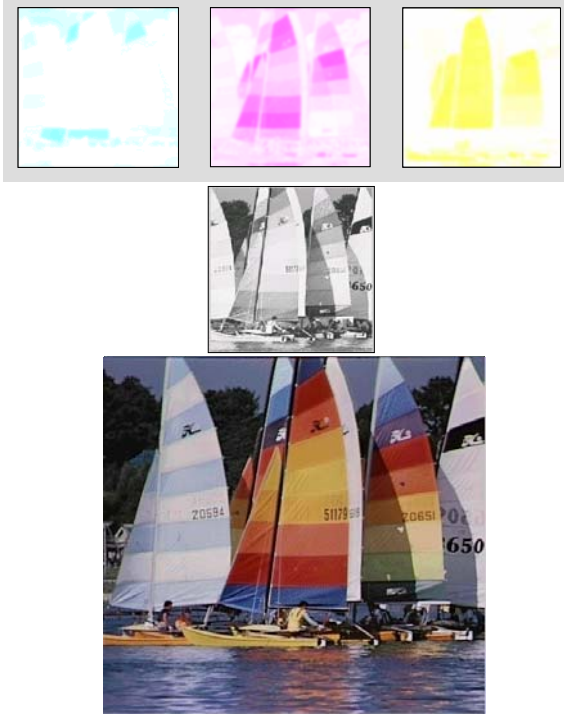
K

K(x,y) = min(C(x,y),M(x,y),Y(x,y))

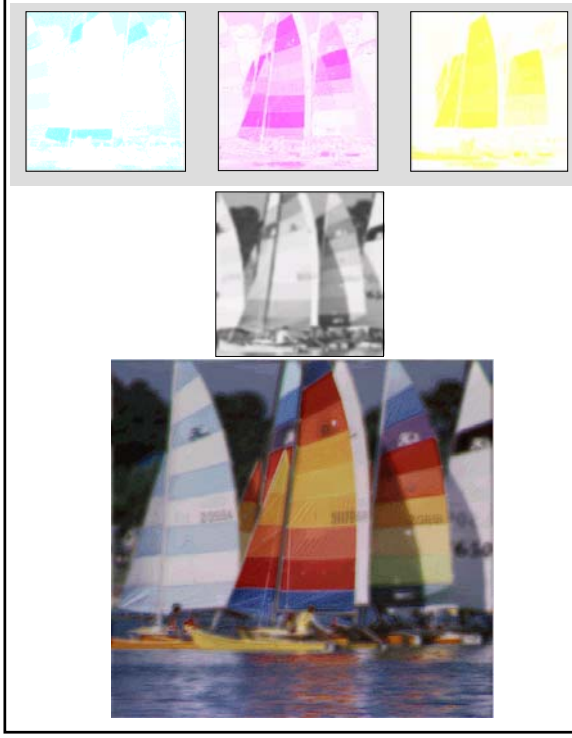
CMYK Separations With GCR



Spatial Effects: CMY All Blurred

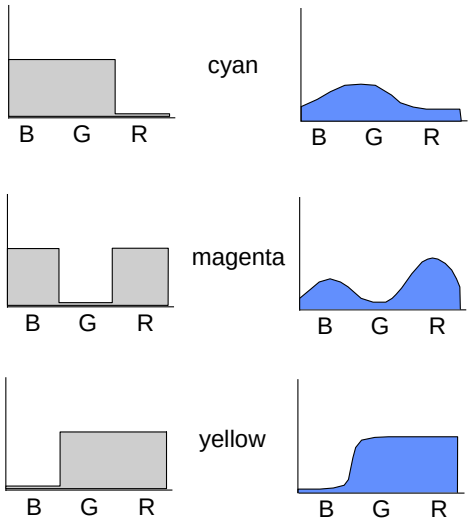


Spatial Effects: only K Blurred



Ideal Block Dyes vs Printer Dyes

Ideal block dyes: Actual Printer dyes:

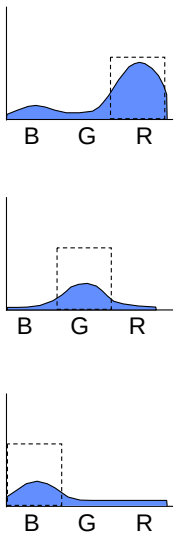


Problems with Printer Dyes

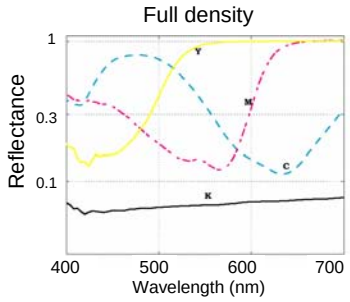
red = magenta+yellow:

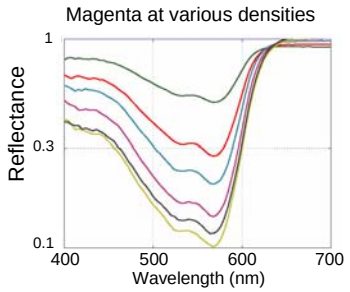
green = cyan+yellow:

blue = magenta+cyan:



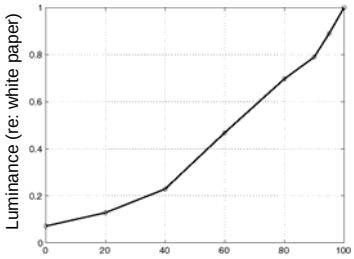
Example: Reflectance Spectra of Real Inks



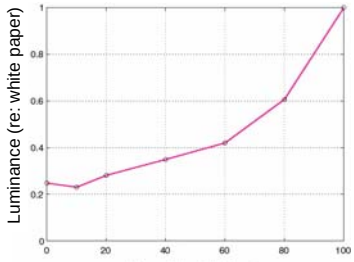


HP printer

Tone Reproduction Curves

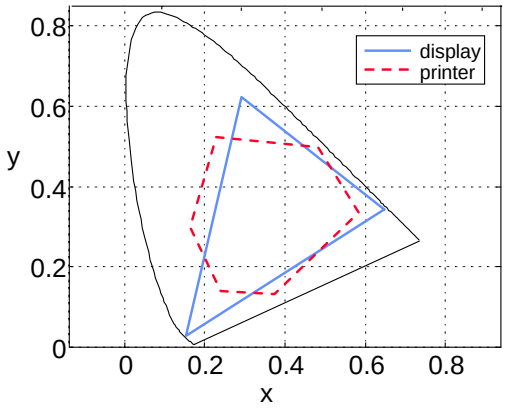


Black ink level (dv)



Magenta ink level (dv)

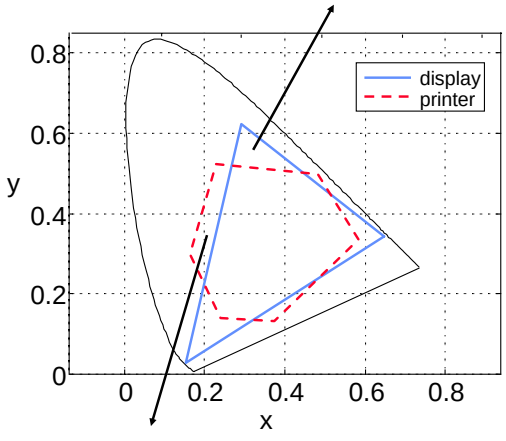
Printer Gamut



Colors within the Gamut can be printed.

Gamut Mapping

How does one print this color?



This color never needed?

Monochrome Printing

GrayScale

Threshold

Halftoning