Colour and the Printing Process

Resolution

Please note that when a digital image is created there is a **fixed** number of pixels in that image. The pixels are arranged in rows and columns. Another name for pixels is dots. Ultimately the image has to occupy a given length and width. The number of pixels or dots for any given length is known as **resolution.**

The standard measurement in the printing industry is the inch, which is approximately 2.2 cm long, a little longer than twice a centimetre. Resolution is measure in terms of how many dots (pixels) occupy one inch. This is known as **dots per inch** or **dpi**. The more dots per inch, the higher the resolution, the more detailed and image will be.

DPI is calculated by dividing the numbers of dots by the number of inches. For example, If an image is 1000 pixels wide and occupies a width of 10 inches, 1000 divided by 10 is 100 dpi.

There are 3 possible values: the number of dots, the number of inches, and the dots per inch. Given any 2 values you should be able to figure out the third value.

Resampling down is the term used to reduce the number of pixels. Pixel information is discarded an lost forever. This is done through a process called **interpolation**.

Resampling up is the term used to increase the number of pixels. Keep in mind that the new pixels are being created from the original image and don't necessarily give you a higher quality image. This is done by **extrapolation.**

Colour Modes

There are 2 kinds of colour modes, one for print (CMYK)and one for screen display (RGB).

RGB uses light to create colour. The RGB colour mode is used for a screen display like a television or computer screen. Light consists of Red (R), Green (G) and Blue (B) light rays, when mixed in the correct combinations, become any colour in the visible spectrum. It is also known as an "additive" colour model. You combine or add combinations of each light to create colour. Red plus Green plus Blue equals white.

CMYK uses ink to create colour. This is used for print. When ink is mixed it subtracts light, more specifically it reduces the amount of light that is reflected from it. Since light gets absorbed from a printed page, it is known as a "subtractive" colour model. Colour is made from variations of reflected light.

CMYK is also known as "Process Colour". There are 4 inks that are used to create continuous tones. They are Cyan (C), Magenta (M), Yellow (Y) and Black (K) ink. (Black cannot be labled B, because that is already used for Blue, therefore, it is labled with a "K".) Rather than mixing the inks to create colour, paper is sent through the printing press 4 times, one with each colour of ink. They are printed using overlapping patterns, which creates the illusion of colour. (More information on the section half tones.)

When you print variations of cyan, magenta and yellow ink in patterns, you get many colours, however, it cannot adequate produce a true black. The colour is at best, a muddy brown. Why? The inks are not as pure . Therefore, a fourth ink (Black) is used to compensate for this.

Understanding Colour Depth

Computers store information in the form of bits. Bits contain one of two values, O and 1. Therefore, with regards to colour information, bit can only store one of two colours. The number of digits in a number of bits in a colour. The more bits there are in a number, the more possible combinations, the more colours.

1 bit colour has only 1 x 2, 2 colours
Example: 0

2 bit colour has only 2 x 2, 4 colours
Example: 01

4 bit colour has 2 x 2 x 2 x 2, 16 colours
Example: 1010

8 bit colour has 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2, 256 colours
Example: 0101 0101

24 bit colour has 256 x 256 x 256 colours, which is 16 777 216 colours.
Example: 1010 1110 1010 1110 1010 1110

Indexed Colour (Palletted) vs True Colour

1 bit, 2 bit, 4 bit and 8 bit colours have an limited number of colours to choose from. Each of these colours can be referred to as a different number. When referring a number to a colour it is known as "indexing". You can say the colour is "indexed colour". 1, 2, 4 and 8 bit colour are indexed colour because there is a limited number of colours in their colour pallette.

Since there are over 16 million colours to choose from in the RGB colour model, the difference between one colour and the next is so small that the human eye cannot see it. 24 bit colour is also known as "true colour". True colour can be derrived from different intensities of 3 colours: R, G and B. Each colour is numbered from 0 to 255. Since O is counted as a number, there are 256 variations of red, green and blue. When you combine the three colour components you get 256 x 256 x 256 combinations of colour. That's over 16 million colours.

Greyscale is the spectrum without any colour to speak of. It goes from white to black to every shade of grey in between. When you mix equal amounts of R, G and B the colour cancells each other out. There are 256 colour values in each colour, numberin 0 to 255.

R 0
G 0
B 0 is black

R 255
G 255
B 255 is white

Since there are only 256 instances when R, B and G can be equal, there are only 256 shades of grey. (2 x 2 x 2 x 2 x 2 x 2 x 2 x 2). This is 8 bit colour, or 8 bit greyscale.

Economics, Black and White, Spot Colour and Process Colour

Before we discuss the different kinds of print jobs, it is wise to discuss economics. In order to make printed material from a newspaper to a full colour magazine, you must send paper through the printing press. It can be sent as few as one time, or as many as five time. Each time you send paper though the printing press, a company pays for labour, materials and wear and tear on the equipment. The more times you send paper through a printing press, the more money it costs. In order to keep costs down, you must decide what kind of a print job will suit your needs.

Printing in black and white is also known as printing in grayscale. Only one colour of ink is used, black, but it is printed in various intensities from white, to many shades of grey, to black. The computer usually stores a black and white job as 8 bit grayscale, meaning that there are 256 shades of black ranging from white to black. It sent through the printing press only once.

In the printing industry there are there are 2 processes in which colour can be added to paper: spot colour and process colour.

Spot colour is a premixed colour of ink. It only goes through the printing press once; however, it is usually added to a black and white print job, in which case, the paper goes through the printing press twice, once for black and white and once for spot colour. You can print various intensities of the spot colour from light to dark, but the colour itself does not change. This is known as a two colour job. One example of its use is a black and white brochure, with a splash of colour, but it is used as a compromise to full colour. Printing a spot colour page is more economical than using the CMYK process. Why? They only have to send it through the printing press twice as opposed to four times. Less time and less labour means spending fewer dollars are spent.

The CMYK colour model or process colour uses various intensities of Cyan, Magenta, Yellow and Black ink. It is also known as full colour job. When a colour page is created it is sent though the printing press 4 times, once for each colour of ink. When you see colour on a printed page it is really an illusion. The Cyan, Magenta, Yellow and Black Tints are overlapped into different patterns. This is known as a four colour job.

Continuous Tone vs. Half Tones

Continuous tone is a full tonal range as what you see on the television, a computer screen in the 24 bit RGB colour mode, or a colour photograph. At the printing press, it is not possible to print continuous tones, so an image would have to be converted to a **halftone.** The continuous tone is converted to a pattern of solid dots, which gives the **illusion** of a continuous tone.

Halftone Black and White (Grayscale)

When black and white image is printed at the printing press. Another name for a black and white image is **grayscale**. It consists of a series of dots ranging from really big or really small, and if there is no colour (white), there is no dot at all. Halftones are dots that are printed in rows and columns 90^{O} to each other.

When a job uses only one colour, the pattern of the rows of dots are arranged at a 45^{O} angle. Why? If they are arranged in horizontal rows then, one would pay more attention to the dots themselves as opposed to the image. Therefore, a black and white job with no other colour would be printed at 45^{O}.

How is intensity of colour measured? It is measured using a percentage. For example, black is used to print grayscale images. If one part of the image is completely is black, it is called 100% black. If the part of the image is white and has no black in it whatsoever, it is called 0% black. If the colour is a midtone gray, between the intensity of 100% black and 0% black, it is called. 50% black.

How does a printer, print a grayscale image? It is printed using what's called a **halftone cell**. The halftone cell is further broken down into rows and columns, a grid like pattern much like your original digital image.

Consider an image which is 8 bit grayscale, which is the standard for black and white printing. Each pixel in the original digital image can be one of 256 possible shades of gray. Also, each pixel make a half tone cell which is 16 pixels wide by 16 pixels high. 16 times 16 is 256 pixels. The more pixels that are coloured black, the darker the halftone.

If the halftone cell is 100% black, all 256 pixels in the halftone cell are filled.
If the halftone cell is 0% black, none of the pixels in the halftone cell are filled.
If the halftone cell is 50% black, 128 of the pixels are filled.

Halftones Used in Full Colour

As mentioned, if only one colour is being printed, a 45^{O} angle is the optimal choice. However, if you are printing more than one colour, than what looks best is if the colours are printed at 30^{O} angles to each

other. (This is a blind faith statement. According to the print experts, this is what looks best.)

This poses a problem when printing a 4 colours print job like process colour. Why? You can have 30^{O} separating the first and second colour. You can have 30^{O} separating the second and third colour. However, if you have 30^{O} separating the third and fourth colour, you now have 90^{O} separating the first and fourth colour. (Remember, halftones are printed in rows and columns which are 90^{O} to each other.) You have now printed on colour on top of the other.

How do printers do to overcome this problem? They print the fourth colour in between the second and third colour. You now have 30^{O} separating the first and second colour, 15^{O} separating the second and fourth colour, and 15% separating the fourth and third colour. The first, second and third colour are still 30^{O} away from each other! Which colour do they pick? Because yellow is the lowest contrast against white, this becomes the fourth colour.

What does this look like under a microscope. Remember the colours are overlapping to create and illusion, not mixed. The pattern is known as a **rose** pattern.

One example of a four colour print job will have black printed at 45^{O}, magenta at 75^{O}, yellow at 90^{O} and cyan at 105^{O}. (Please note that there is 30^{O} between black and magenta, and between magenta and cyan.)

Even as little as being 1^{O} off will cause the colours to appear strange. This is called a **moire** pattern.

Screen Frequency or Line Screen of a Halftone

Both terms describe the same thing, but are described in different ways. The screen frequency to prepare an image for the printing press is described in terms of lines per inch or LPI. Or one can describe it in terms of line screen (LS) of a halftone. A 150 LPS has a 150 LS.

Screen Ruling

Screen Ruling is the number of halftone dots counted per linear inch; it is measured along the axis of each row of dots. It is written using a number followed by the number sign, for example, a screen ruling of 150 halftone dots per inch is written as 150#.

Screen Angle

Simply put, the screen angle is the angle in which the halftone dots of the screen are printed

Halftone Dot Range

The minimum to maximum range of halftones is always measured as a percentage. 0% is white, 100% is a solid colour, however, practically speaking it is difficult to print the whole range. A halftone dot range spanning 15% black to 85% black is 70%

Highlights, Shadows and Midtones

High light is the lightest areas of an image.

Shadow is the darkest area of an image.

Midtones are the areas between the highlight and shadow.

Dot Shape

There are 3 dot shapes: elliptical, round and square. Suffice it to say that there are advantages and disadvantages to using each. Selecting one of the 3 lies on the expertise of the printer.