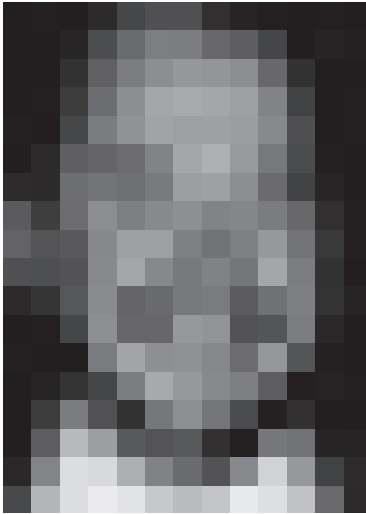


# Printing Services *FactSheet*

Vol. 11, No. 5

Digital Imaging for Print Media

October 2005



**Figure 1.** A very low resolution digital image where each pixel is visible.

**D**igital imaging requirements for offset print media are among the most stringent in the realm of imaging. With the advent of high-quality, low-cost scanners and now, high-quality, low-cost digital cameras, digital images have virtually taken over traditional photographic imaging. This FactSheet covers several concepts and processes that should help you make digital images look great in print media. Keep in mind that computers can manipulate two kinds of images, bitmapped images, which are the digital images that are covered here, and vector images. For more information on vector images, check out our Design Basics for Offset Printing FactSheet. And remember, always consult with your printer (person who puts ink on paper with a press, not laser printer) before you get too far into any print project.

### Digital images defined

Digital images are created by taking a photo with a digital camera or by scanning a photographic print. They are comprised of an x-y array of square dots called pixels (Figure 1). The terms “dot” and “pixel” are interchangeable. The term pixel is short for picture element. Each pixel in a digital image is assigned a color. Programs such as Adobe Photoshop allow you to zoom in on images to the point where individual pixels can be viewed.

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132 Union Drive  
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294-0008

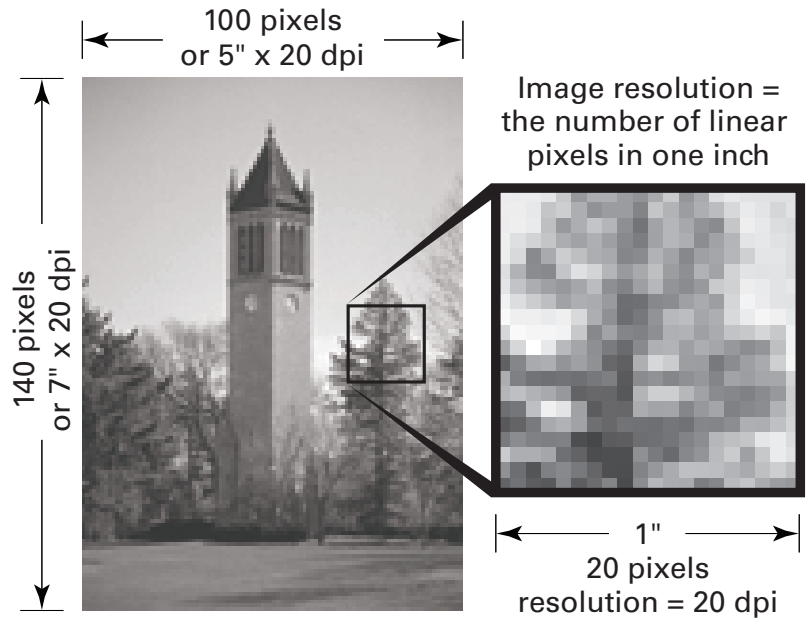
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# Digital Imaging for Print Media

## Image size

The “size” of a digital image can be defined in three ways (see Figure 2). The first way is total pixel dimension. This is simply the total number of pixels in the x and y dimensions. The second is size in inches multiplied by resolution, where resolution is defined as the number of pixels in one linear inch of a digital image. When referring to image resolution, the terms dots-per-inch (dpi) and pixels-per-inch (ppi) are the same thing. Resolution times image size (in inches) equals total pixel dimension. The third way is file size (kilobyte or KB, megabyte or MB, gigabyte or GB). To view all three values for a digital image, open the image in Photoshop and go to the *Image* pull down and select the *Image Size* option (see *Photoshop Image Size* informational panel on the opposite page).

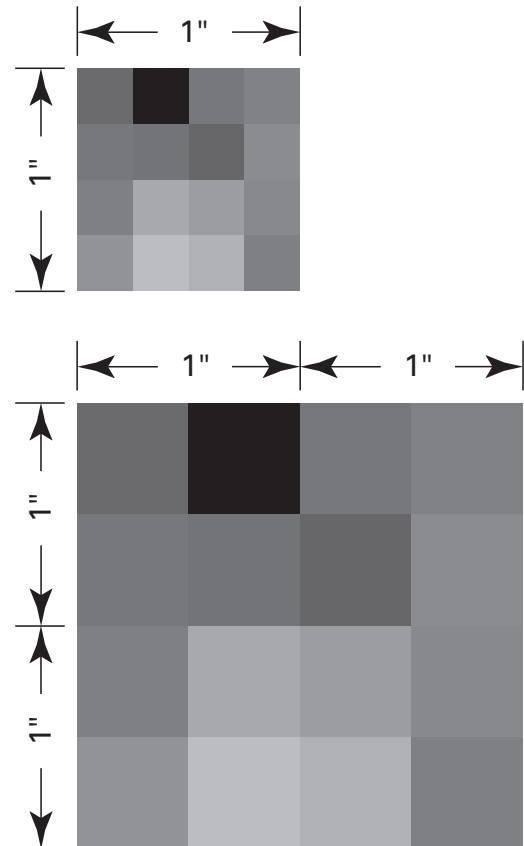


**Figure 2.** Two of the three ways of defining image size (left). Image resolution defined (right).

Digital cameras are often characterized as being able to capture a certain number of megapixels (one million pixels). This is derived by multiplying the number of total pixels in the x dimension by the number of total pixels in the y dimension that the camera can capture. For example, an image from a 5 megapixel camera may have a total x pixel dimension of 2,592 pixels and a total y pixel dimension of 1,944 pixels.  $2,592 \text{ pixels} \times 1,944 \text{ pixels} = 5,038,848 \text{ pixels}$ . Camera manufacturers usually round to the nearest 100,000 pixels when advertising a camera’s megapixel size.

By changing the size of a digital image without resampling (without adding or deleting pixels), the resolution of the image changes, but not the total pixel dimension. A very simple example is a scan that is four total pixels square (Figure 3). If the width and height of this scan is 1-inch, the resolution of the scan is 4 dpi. If the scan is doubled in size so the width and height are 2-inch, the resolution is halved to 2 dpi.

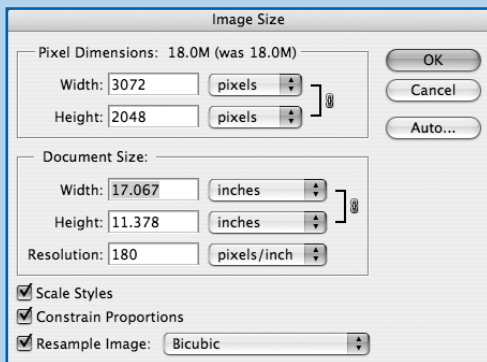
Another example is a grayscale scan with a total pixel dimension of 1800 pixels x 1800 pixels (3.09 MB file size). This scan is the same “size” as a 6-inch x 6-inch image with a resolution of 300 dpi (6 inches x 300 dots/inch = 1800 dots) or a 25-inch x 25-inch image with a resolution of 72 dpi (25 inches x 72 dots/inch = 1800 dots).



**Figure 3.** Simple digital images with resolutions of 4 dpi (top) and 2 dpi (bottom).

## PHOTOSHOP IMAGE SIZE

In Photoshop, the best tool to view all information about image size (wouldn't you know it) is the *Image Size* menu. To access this menu, open your image in Photoshop, go to the *Image* pull down, then to the *Image Size* menu. At the top of the menu you can view the total pixel width and height of the image as well as the file size of the image. Located in the middle of the menu is the "Document Size" width and height of the image, which you can set to the unit of choice, such as inches. Below that is the resolution of the image, which you can also set to the unit of choice, such as pixels per inch. At the bottom of the menu there are two options that you can toggle on or off, constrain proportions and resample image.



When resample image is clicked off and constrain proportions is clicked on, you can key in a different width value in the document size field and the height of the image will change to reflect the same proportion. Also, the resolution value will change but the total pixel dimension and file size will not. This illustrates what happens when an image is placed in a layout and enlarged or reduced. That is, the resolution changes. Enlarging the image reduces the resolution (fewer pixels per inch). Conversely, Reducing the image increases the resolution (more pixels per inch).

When resample image is clicked on and you key in a different width value in the document size field, the height value of the image will change to reflect the same proportion, but the resolution value will stay the same and the total pixel dimension and file size will change. This effectively adds or removes pixels from the image. Thus the term, resample. Another way to resample is to click resample image on and change the value for resolution. The width and height in the document size fields will stay the same, but the total pixel dimension and file size will change.

Do not resample an image to a higher resolution. Too often, low resolution images are resampled to a higher resolution with the expectation that the two-times rule (defined later in this publication) will be satisfied and the image will then look good in print. This is not true. Photoshop adds pixels, but it does not necessarily do it in an effective manner. The "jaggies" just become a little rounder looking. There are instances when resampling an image to a lower resolution is desirable, as described in the last paragraph of the Two-Times Rule section.

## Color space

Another attribute of digital images is color space. In Photoshop this information is displayed at the top of the image after the file name. Color space can also be viewed and changed in the *Image, Mode* pull down. Typically, digital photos and scans are automatically created in the RGB (red, green and blue) color space. This is an "additive" color space as opposed to a "subtractive" color space such as the CMYK (cyan, magenta, yellow and black) color space. Additive color is perceived when light from a direct color source such as the monitor on your computer or your television hits your eye. Subtractive color is perceived when light such as sunlight reflects off of pigment such as ink on paper. Some colors of the color spectrum are absorbed into the ink pigment (subtracted) and others are reflected. Your eye perceives the reflected color.

RGB images must be converted to CMYK before they can be used in the four-color offset printing process. It is very important to set a preference in the *Color Settings* menu under the *Edit* pull-down before you do this (Figure 4). In this menu, the CMYK setting under "Working Spaces" is what determines how the RGB colors are going to convert. Ask your printer what setting to use. They may want to do the conversion for you or they may have a profile for you to use. Otherwise, use the U.S. Web or Sheetfed Coated options if your printed piece is going to be on a coated stock and U.S. Web or Sheetfed Uncoated if it will be on uncoated stock. To change an RGB image to CMYK after setting the CMYK profile in Color Settings, simply go to *Image, Mode* in Photoshop and select the CMYK option.

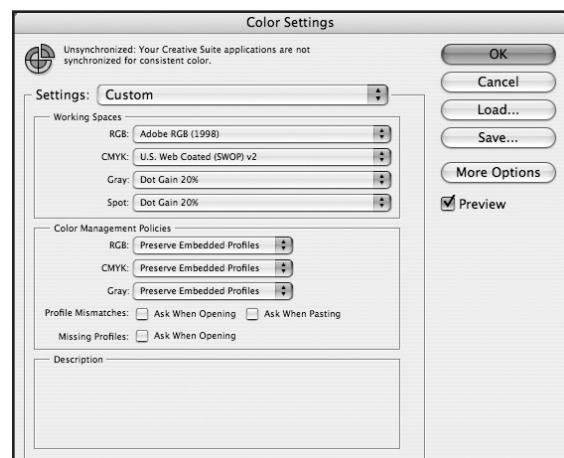


Figure 4. Photoshop Color Settings menu.

When printing an RGB image to a color inkjet or color laser printer, it is not necessary to convert to CMYK. The printer or print driver will do the optimal conversion for you on the fly.

Different color spaces have different color “gamuts.” That is, they can contain different ranges of color. RGB has a larger gamut than CMYK. Lab (lightness, color channel a and color channel b) has a larger gamut than RGB and CMYK. One method of converting to CMYK is to first convert to Lab from RGB and then, from Lab to CMYK. This can remap colors more accurately.

Other color spaces include bitmap, grayscale, and indexed color. Bitmap is black and white only. Grayscale typically uses 256 shades of gray and is used for black and white photos. Indexed color is used for Web graphics. Indexed color images are saved in the GIF format (.gif extension) and are reproduced with 256 or less colors, resulting in fast Web downloads. In comparison, RGB and CMYK images can contain millions of colors. Avoid using indexed color images in print media.

The best practice is to always make a copy of your original RGB digital image, then use the copy to make color space changes and other alterations. Save the original. This maintains the maximum color gamut of the image for different applications later on. For example, when you convert an RGB image to CMYK, you lose or “clip” colors because CMYK has a smaller gamut. If you then convert back to RGB from CMYK, even though RGB has a larger gamut, those colors are already lost.

### Image compression

Most digital cameras save images in the JPG or JPEG format (.jpg extension). This is a “lossy compression” format meaning that the software in the camera makes a decision on how to average pixel colors in certain parts of an image, eliminating detail, but making the file size smaller when the image is saved. The JPG format offers several levels of compression. Higher compression settings result in smaller file sizes and lower-quality images. JPG “noise” (Figure 5) is easily seen in low quality JPG images. Inversely, lower compression settings result in larger file sizes and higher-quality images. Camera modes on digital cameras usually use lower compression/higher qual-

ity JPG settings. In Photoshop, when saving a JPG file, you can choose the desired compression level.

When you open a JPG file in Photoshop and make a change to the image and resave the image as a JPG, more “noise” can be introduced into the image. This can happen even if no changes are made to the image. This degrading effect is accumulative from JPG save to JPG save. It’s best to save JPGs in another non-compressed format such as TIF (.tif extension) after opening them in Photoshop the first time. Most digital cameras have modes which save as TIF or RAW format. These non-compressed formats result in larger file sizes, but JPG “noise” issues are eliminated.

Many people make the mistake of using digital camera settings that result in more pictures on the camera’s memory card. These images typically have resolutions that are too low to work well in print. It’s best to use the highest resolution settings in a non-compressed save format when shooting digital photos for print. High-quality JPG files usually work well in print also.



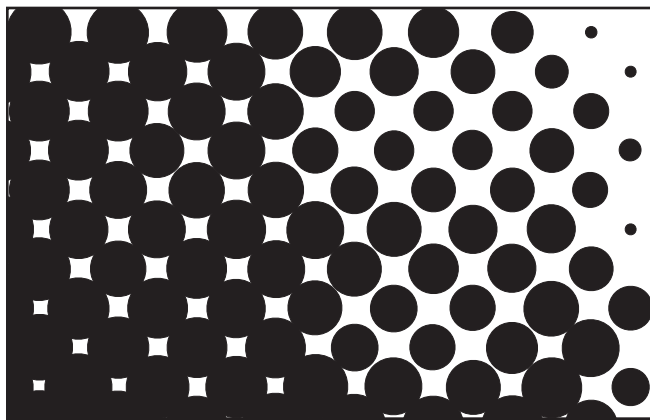
Figure 5. Example of JPG “noise.”

### Screens and printers

So far, digital images have been defined, but what happens to them when they are printed? Different types of printers reproduce images using different methods of “screening.” For example, if you look through a magnifier or loupe at a photo printed on a newer inkjet printer, you may see a “stochastic” screen, or one that looks sort of like grain in a photographic print. Small dots of different colors of inks visually define the image. The screens on a typical color laser print may look like a series of multicolored, variable-thickness parallel lines when viewed up close.

The kind of screening that is used in offset printing is basically the same kind of screening that a typical black and white laser printer produces. It is called halftone screening. Halftone screening has been used in the printing industry since the mid 1800s. It was adapted for laser printer technology at the beginning of the desktop publishing revolution with the advent of the Postscript page description language.

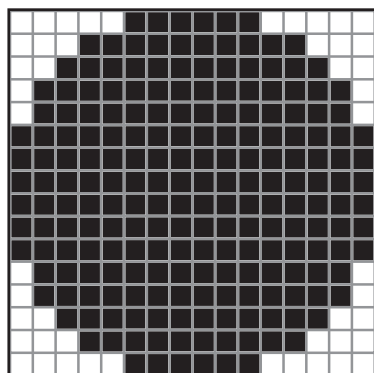
Take a loupe or magnifier and look closely at a photo in your morning newspaper (Figure 6). Now look at a photo printed on a black and white laser printer. Up close, the images should look very similar.



**Figure 6.** Closeup of a halftone screen.

Black and white laser printers put down spots of toner on paper. The number of spots per inch is defined in dots-per-inch (dpi). This should not be confused with the resolution of digital images. A typical laser printer has a resolution of 600 dpi.

To simulate the gray values in a digital image, a laser printer “builds” a halftone dot out of a small array of spots, called a cell, turning some spots on and some spots off (Figure 7). Within a cell, the size of



**Figure 7.** Halftone dot built from laser printer spots within a cell.

a halftone dot can vary from small to large. Visually, the combination of the black (on) spots and the white (off) spots is like mixing black and white paint. The result is gray. Add more black paint (toner, ink) and the gray is darker. Less black

paint makes lighter gray. If the spots in a cell are all off, the result is a simulation of white. If the spots are all on, the result is a simulation of black. When a digital image is processed by a laser printer, light areas are interpreted as small halftone dots and dark areas are translated as large halftone dots. Visually, the paper color acts like the white paint.

Halftone images have two attributes: the number of halftone dots per inch (not the same as the dpi resolution of a laser printer) and the angle of the grid of halftone dots. “Lines per inch” (lpi) is the unit name for the number of halftone dots per inch. This is referred to as the line screen frequency of the halftone. This is a printing term and technically means the number of cells per inch on a laser printer (remember, each cell contains a halftone dot). The angle of the grid of halftone dots is called the screen angle. For single color halftones, this is usually 45° (see Figure 6).

In the offset printing process, “plates” are mounted on a printing press and transfer ink to the desired location on paper. Plates are very thin and flexible and are typically either a polyester material or a metal such as aluminum. Plates are imaged on a glorified black and white laser printer called an imagesetter or platesetter. For image reproduction, these devices produce a halftone screen just like a typical black and white desktop laser printer. The halftone dots on the plate “hold” ink on press and transfer it to paper resulting in halftone dots of ink on paper.

Platesetters use a photo process rather than a toner process and print at much higher resolutions than regular laser printers (2540 dpi at Printing Services). Halftone line screen frequencies (lpi) can be set to different values in order to accommodate different printing conditions and papers. 85 lpi is typically used in newsprint. This is the same line screen frequency that a typical black and white desktop laser printer uses. For uncoated stocks, line screen frequency is usually set to 133 lpi. For coated stocks, frequencies may be set to 150, 175 or even 200 lpi and beyond. Printing Services uses a 133 lpi screen frequency for uncoated stocks and a 150 lpi screen frequency for coated stocks.

## Two-times rule

There is a handy rule-of-thumb that can be used to tie all of this information together when using digital images in an offset-printed publication. It's called the two-times rule. For digital images that are taken with a digital camera, this rule calculates how large you can use the image in an electronic layout in order to retain quality in the final offset-printed piece. For digital images that are created by scanning a photographic print, it calculates what resolution your scanner should be set to before scanning, in order to retain quality in the final offset-printed piece. This rule of thumb applies to offset printing. When printing directly to a color laser or inkjet printer, images generally print acceptably at lower resolutions. Newer large-format color inkjet printers or plotters are particularly forgiving of lower resolution images.

Let's start with an example using an image taken with a digital camera. As mentioned earlier, photos are often taken at lower resolutions in order to fit more images on to a camera's smart media. Suppose you shoot a picture that has a total pixel resolution of 640 pixels wide x 480 pixels tall with a digital camera. This results in a small file, but how large can you make this photo in a newsletter layout that's going to be printed on uncoated stock? Assuming that the width of the photo is the dimension that needs to be calculated, the formula looks like this:

$$\text{width (in inches)} = \frac{\text{total horizontal pixel dimension}}{2 \times \text{line screen frequency of printed newsletter (lpi)}}$$

We know that the total horizontal pixel dimension is 640 pixels. Since the newsletter is going to be printed on uncoated stock, we know the line screen frequency will be 133 lpi. Plugging these values in, we get: width in inches =  $640 / (2 \times 133)$  or width = 2.4 inches. If this image is enlarged in the electronic layout to slightly larger than 2.4 inches, it will most likely still look good in the printed newsletter. If it is enlarged too much, it will begin to look "soft." If enlarged way beyond what the two-times rule calculates, individual pixels will become visible in the printed piece. We call this the "jaggies" (Figure 1).

Now let's look at an example where we have a photographic print that needs to be scanned. This image is going to be used in the same newsletter as the previ-

ous example. It's a 6-inch wide x 4-inch tall print and we want it to fill a 3-inch-wide column. What resolution do we need to set the scanner to in order to make this photo look good in the newsletter? The formula looks like this:

$$\text{scan resolution (dpi)} = 2 \times \text{line screen frequency of printed newsletter (lpi)} \times \text{enlargement or reduction factor}$$

We know the line screen frequency is going to be 133 lpi. We also know the enlargement or reduction factor. Since the photo is going to be half the size of the original print, this factor is .5. If the photo were to be doubled in size, the factor would be 2. If it were to be used at the same size, the factor would be 1. So, plugging in the numbers, we get: scan resolution (dpi) =  $2 \times 133 \times .5 = 133$  dpi.

Since most scanners typically have a native optical resolution of 300, 400, 600, or 1200 dpi, you will get a cleaner scan if you scan at the next highest native scanner resolution from the two-times rule calculation. In this case, it is best to scan the photo at, say, 300 dpi, resulting in a scan file larger than you need for a good halftone. Then, in Adobe Photoshop, you can open the scan, go to the *Image, Image Size* window, click the Resample Image on, set the image size to half the original photo size (enlargement factor of .5) and a resolution of 266 dpi ( $2 \times 133$  lpi). This will satisfy the two-times rule and minimize the file size of the scan resulting in faster printing and less hard drive usage.

## Other scanning considerations

Most scanning softwares provide settings that allow you to tell the scanner what kind of scan to do. There are usually four modes: line art, also known as bitmap or 1-bit; grayscale, also known as black and white photo or 8-bit; and color, also known as RGB or 24-bit. Use line art to scan logos or images with solid-only areas. Do not use the two-times rule for this kind of scan. Scan line art at the highest optical resolution of your scanner. Use grayscale to scan photos that are going to be printed in one color of ink. Use the two-times rule for these scans. Use the color mode to scan photos used in full-color publications. Use the two-times rule for these scans.

Some scanning software also allows you to save your scan as a halftone. Never use this function. Let the laser printer create the halftone. There may be a mode that allows you to compensate when scanning an image that is already a halftone such as a photo cut out of a newspaper. This is okay because it can eliminate a moiré pattern in the final printed piece. This function may require you to know the line screen frequency of the halftone you are going to scan. If your software has a halftone mode, check the manual for the actual function of this mode. If you scan a halftone using the grayscale or color mode, you may be able to eliminate moirés by using the Despeckle filter in the *Filter, Noise* pulldown in Photoshop.

Plan ahead for crops. Keep in mind that you may need a higher resolution scan to satisfy the two-times rule when you crop a photo.

Save scans as TIFFs (tagged image file format). Exceptions to this include Photoshop cutouts using clipping paths and Photoshop duotones which require that the image be saved as EPS (encapsulated PostScript) files.

### Gray value adjustment

In print media, it is important to make sure that the darkest areas of a grayscale scan are not too dark and the lightest areas are not too light. By using the *Image, Adjust, Levels* window in Photoshop (Figure 8), you can adjust the lightness or darkness of your scan. In the *Levels* window note the “Input Levels” histogram.

There are three sliders below it. The middle slider will allow you to lighten or darken the whole image as you see fit. Also, note the “Output Levels” slider at the bottom of the levels

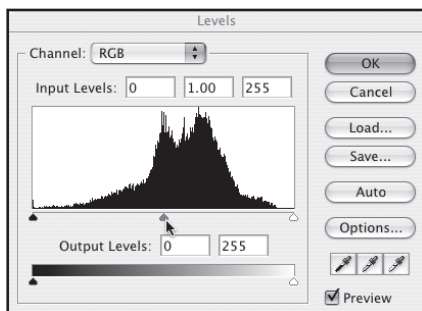


Figure 8. Photoshop Levels menu.

window. This allows you to ensure a good shadow dot (little white dot) in the darkest area and a good highlight dot (little black dot) in the lightest area of your scan when output as a halftone. With the *Windows, Palettes, Show Info* window open (Figure 9) along with the *Levels* window, move the pointer over the darkest area of your scan. If you can find an area that is darker than 92% K (K stands for black in printer's lingo) as noted

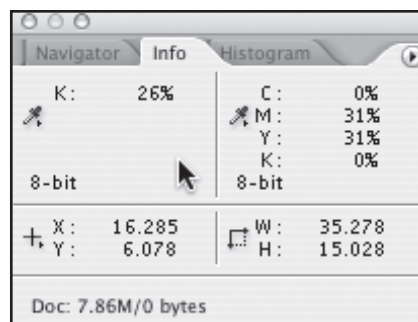


Figure 9. Photoshop Info menu.

in the *Show Info* window, move the left output levels slider in the *Levels* window to the right until the darkest area is 92%. Likewise for the lightest area of the scan. Use the

right output levels slider to make sure there is no area lighter than 2%. Of course, there are exceptions to this rule. Check with your printer.

### Color correction using gray value

Here's a quick and effective method to correct badly tinted scans. Color tinting is usually introduced when photographic film is processed, scanned or aged and typically is not a problem with digital photographs. This method involves visually identifying “gray” areas in digital images. The color gray ranges from pure white to pure black. Most photos contain an object that is gray in color such as white shirts, black shoes, computers, concrete, chrome, hair, etc.

Consider a scan of an old photograph of a marching band with instruments. Let's say that over time, the print has turned slightly magenta and the scanning process has actually increased this tint so flesh tones look too red. The scan is also in the typical RGB color

space. Open the image in Photoshop. Go to the *Image, Adjustments, Curves* menu (Figure 10). In this menu you will see three eyedropper icons in the lower right part of the menu.

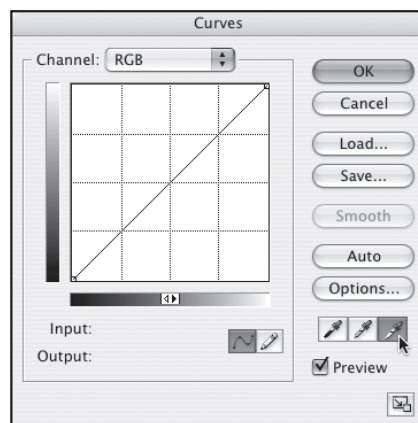
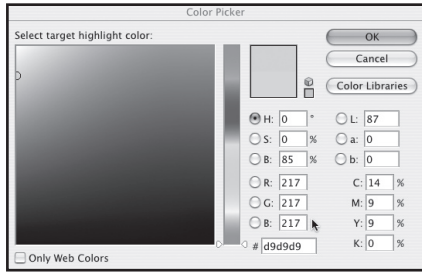


Figure 10. Photoshop Curves menu.

Now look at the image. A

lot of bands have white shirts and black pants. Instruments are often silver. Drums are often white. The band might be standing on concrete. Let's say that all of these things are true in this photo. So, let's pick one of these “gray” areas such as a light area of concrete. Since this

is a light “gray,” double click on the right eyedropper, which is the highlight (or light gray) eyedropper. The *Color Picker* menu will now display (Figure 11). In the *Color Picker*, there are several ways to pick a color. For this method, we are going to use the RGB values. When all three values are set to the same number, a perfect gray will be defined. The values 255, 255, 255 define white. 0, 0, 0 is black. 128, 128, 128 is a 50% gray. Let’s say that the concrete area is a light area. Maybe around 15% gray at first guess. This translates into about 217, 217, 217 in RGB. By setting the RGB values in the *Color Picker* to 217, 217, 217, and then clicking OK, you are assigning that value of gray to the highlight eyedropper. With that eyedropper tool selected in the *Curves* menu, you can click on the gray concrete in the photo and force a 15% gray to be assigned to that area. All other colors in the image change relative to that forced gray color change.



**Figure 11.** Photoshop Color Picker menu.

Since the light gray concrete area should have a red tint initially, when you click the eyedropper tool on that area, you are forcing Photoshop to change that pink concrete to gray concrete. At the same time, the red tint in the rest of the photo should be reduced or eliminated. It’s best to click on an area, observe the changes, undo the edit and try another area until you are satisfied with the overall color. You may need to go back into the *Color Picker* by double clicking on the eyedropper tool again and set the RGB values to a different light gray and try again. You can also find a middle value of gray in the image and use the middle gray eyedropper or a dark gray and use the left dark gray eyedropper. The goal is to end up with flesh tones that look good. Once you are satisfied with the color, click OK in the *Curves* menu and save the image.

## Sharpening

There are several sharpening filters in Photoshop that can be used to enhance your digital images whether they are going to be used in print or on the Web. The *Unsharp Mask* filter is a commonly used one. Originally, unsharp mask was a process used to sharpen photographic prints using darkroom techniques. The term has carried over to the digital age where it really has nothing to do with unsharpening or masking.

This filter works visually on “edges,” or the delineation between light and dark areas. On the dark side of an edge, it makes the image slightly darker and on the light side of an edge it makes the image slightly lighter. Visually, this appears to sharpen the image. Too much unsharp mask creates a halving effect.

To access the *Unsharp Mask* filter, go to *Filter, Sharpen, Unsharp Mask* in Photoshop. This filter has three parameters, Amount, Radius, and Threshold. Amount, as it implies, sets how much effect the filter has on the image. Radius sets the distance on either side of the edge that the filter works. Threshold sets the brightness difference between the dark side and the light side of the edge. The higher the number, the fewer “edges” will be affected.

One typical method is to set the radius to 1 or 1.5 pixels and the threshold to 4 levels. Then, depending on the image, the amount can be set to whatever looks good. This value is usually somewhere between 50% and 200%. Doing two or more *Unsharp Masks* with lesser amounts is another method that some prefer.

Another interesting method is to set the Radius very high at, say 25 pixels, the Threshold at 4 levels, and the Amount very low at, say 25% or less. This can have a more radical, but pleasing affect.

Keep in mind that there are usually several ways to accomplish a task in Photoshop. Don’t be afraid to experiment. Have fun!

for more information, visit:  
[www.print.iastate.edu](http://www.print.iastate.edu)