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How to Calculate Print Resolution

Step By Step

Topics Covered:

- Calculating a print's minimum Pixels Per Inch (PPI) at various print sizes.

This white paper will help you understand how to calculate a print resolution, in Pixels Per Inch (PPI), for a given image. The PPI can be calculated once a dimension (size) is identified for an image. For the purpose of this white paper we are going to use, as an example, an image size of 8" x 10" Width.

It also helps if we know the resolution of the human eye to establish the minimum print resolution. Once we know this, we can then print an image at a slightly higher resolution so the eye can not resolve one pixel from another at a given distance. As long as the print resolution is higher than the eye's resolution, the print will appear to be sharp. There is no need to print everything at highest resolution either. Printing everything at the highest resolution consumes more ink, it takes more time to print, and it creates much larger files.

A little background on eye resolution: A perfect 20/20 vision can resolve a point at a distance at .4 arc-minutes. One arc-minute is 1/60th of a one degree angle. Therefore, a .4 arc-minute is .4/60th of an angle or 0.00667ths of one degree. We use angles, instead of distances, to calculate resolution because as objects get closer to the eye they look larger and vice-versa. We also use arc-minutes to calculate very small fractions of an angle. But .4 arc-minutes is not common for the human eye. The average 20/20 vision of a 20 year old is 1 arc-minute. As we grow older that number increases to 5 (or even higher) arc-minutes but for our example we are going to use a more realistic resolution of 1 arc-minute.

The first step for calculating a print PPI (Pixels Per Inch) is knowing the optimum viewing distance from the print. If the optimum distance is not known, we can multiply the print's diagonal by 1.5. For example, we are going to calculate the PPI for a print with dimensions of 8" x 10":

Viewing Distance (millimeters) = Print Diagonal (millimeters) x 1.5

The print diagonal (in inches) of a 8" x 10" print is equal to the hypotenuse of the print's dimension.

$$\text{Hypotenuse}^2 = \text{Hight}^2 + \text{Width}^2$$

or

$$\text{Hypotenuse}^2 = 8^2 + 10^2$$

or

$$\text{Hypotenuse}^2 = 165$$

or

$$\text{Hypotenuse} = 12.81$$

Now that we have the print diagonal, we can calculate the optimum viewing distance by multiplying it by 1.5:

$$\text{Optimum Viewing Distance} = \text{Print Diagonal} \times 1.5$$

or

$$19.2 \text{ inches} = 12.81 \times 1.5$$

In our example, the optimum viewing distance for our 8”x10” print is 19.2 inches. For simplicity sake we are going to round down to 19 inches. We now need to convert inches to millimeters by multiplying the optimum viewing distance by 25.4 since there are 25.4 millimeters in one inch.

$$\text{Optimum Viewing Distance (millimeters)} = 19\text{”} \times 25.4\text{mm}$$

$$\text{Optimum Viewing Distance (millimeters)} = 483\text{mm}$$

The optimum viewing distance equals to 483mm. We can now calculate the eye resolution by taking the arc-minute formula:

$$p = 2 \text{ x } d \text{ x } \tan\left(\frac{\alpha}{2}\right)$$

p = eye resolution

d = viewing distance (in millimeters)

a = degrees in arc-seconds

Since our formula calls for arc-seconds for 'a' (not arc-minutes) we need to divide 1 by 60 (60 seconds in a minute). That comes out to 0.01667 arc-seconds in one degree:

1 / 60 = 0.016667 arc-seconds

The eye-resolution formula inside the parenthesis calls for dividing the arc-seconds by 2:

0.01667 / 2 = .008333

Then we need to calculate the tangent of .008333 which equals to 0.000145 degrees.

We can now calculate eye resolution ‘p’ by multiplying 2 x the optimum distance (in millimeters) times the tangent of ‘a’ divided by 2:

$$p = 2 \times 483 \times 0.000145$$
$$p = 0.14007 \text{ pixels per millimeter}$$

The result for eye resolution ‘p’ equals 0.14007 pixels per millimeter so we now need to convert it back to inches. Since we have established that there are 25.4 millimeters per inch, we need to divide 25.4 by ‘p’:

$$PPI = 25.4 / 0.14007 \text{ pixels per millimeter}$$
$$PPI = 174 \text{ pixels per inch}$$

We can conclude that the eye can resolve 174 pixels per inch (PPI) on an 8” x 10” image viewed at an optimal distance of 19”. When we print the 8” x 10” image all we need to do is to give it slightly higher PPI so the eye can not discern different pixels at that distance therefore giving it the appearance of being sharp. A PPI of 200 should be more than adequate for a print size of 8” x 10” viewed at a distance of 19 inches.

You can use these steps and substitute any print size dimensions to calculate the minimum PPI.