

# The Basics

In order to achieve consistently pleasing results, you should become familiar with some of the basics, and learn how to use them purposefully in the creative design of your images. We will first take a look at the terms which recur in the art of closeup photography.

## Magnification Ratio

The magnification ratio describes the relationship between the actual size of an object and the size of its image on the film or sensor. A magnification ratio of 1:1 is reached when the object is reproduced in its actual size. This means 1cm in nature corresponds precisely to 1cm on the film or sensor, independently of the format used. When using a ratio of 2:1, the object will be illustrated twice as large as its natural size. Therefore, at a 2:1 ratio, 0.5cm in nature corresponds to 1cm on the film or sensor.

## Circles of Confusion

When a lens is focused, only those points which lie in the plane of focus will appear sharp on the film and/or sensor. All other areas of the image will not be shown as precise points, but rather as circles, called circles of confusion. To a certain degree, our perception will accept these circles as sharply focused. If the size of the circles exceeds this degree, we

## Calculating the Magnification Ratio:

$$\text{Magnification ratio} = \frac{\text{total extension}}{\text{focal length}}$$

The total extension is composed of the focal length of the lens and any lens extension (i.e., a 50 mm lens with a 25 mm extension tube).

$$\text{Magnification ratio} = \frac{50 + 25}{50}$$

$$75:50 = 1.5$$

The attained magnification ratio is 1.5: 1

Natural size  
of object



Magnification ratio 1:1  
on 35mm small  
format film



Magnification ratio 1:1  
on 3/4" sensor



▲ The magnification ratio is completely independent of the camera format.

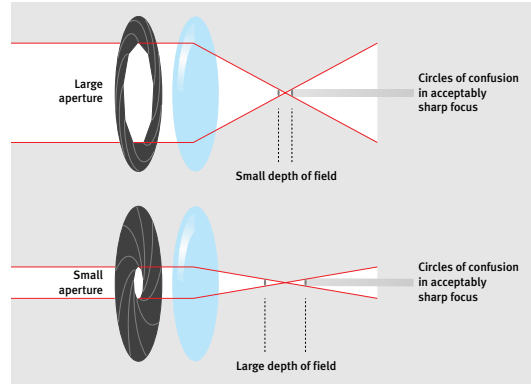


▲ *The shape of the circles of confusion is determined by how many segments the shutter has, (the sample shows 6 segments) and the way in which it is constructed.*

interpret them as out of focus. The camera format dictates how large the circles can be, and still be perceived as sharply focused. The shape of the circles of confusion has no influence on depth of field; the shape of the circles are determined by the shape and number of shutter segments. Ideally, the shutter segments form a circular shaped aperture opening. This rather subjective measurement of quality is called “Bokeh.”

### **Depth of Field**

Depth of field is the distance in front of and behind



▲ *The larger the aperture, the smaller the perceptible depth of field. This is determined by the size of the circles of confusion.*

the subject that appears to be in focus. There is only a single distance at which a subject is precisely in focus, but focus falls off gradually on either side of that particular point, and there is a region in which the blurring is imperceptible. These are the areas in a photograph that the human eye will accept as sharp, and are known as “circles of confusion”. The aperture setting determines both the shutter speed and the maximum depth of field. If you want to achieve a greater depth of field in your image, you must close down the aperture (a higher aperture number). Opening up the aperture (a smaller aper-



▲ From left to right: 50mm, 105mm, and 150mm macro lenses, using the same magnification ratio of 1:3, each at aperture 5.6. The depth of field is the same in all three cases. Using the same magnification within the macro range, the

influence of the focal length on the depth of field will be offset by a change in distance. The picture taken with the telephoto lens shows a significantly smaller portion of the background due to the different viewing angle.

**Table: Depth of Field for 35mm small format film**

Magnification	aperture 2.8	aperture 4.0	aperture 8.0	aperture 16	aperture 22
1:4	3,4 mm	4,8 mm	9,6 mm	19,2 mm	26,5 mm
1:3	2,0 mm	2,9 mm	5,8 mm	11,5 mm	15,9 mm
1:2	1,0 mm	1,4 mm	2,9 mm	5,8 mm	7,9 mm
1:1	0,3 mm	0,5 mm	1,0 mm	1,9 mm	2,6 mm
2:1	0,1 mm	0,2 mm	0,4 mm	0,7 mm	1,1 mm
4:1	0,05 mm	0,03 mm	0,15 mm	0,3 mm	0,4 mm

Calculated with: Depth of Field, magnification ratio, and macro lens calculator, values rounded. <http://www.erik-krause.de/schaerfe.htm>  
 For your own calculations you can find a depth of field calculator at [www.dofmaster.com/dofjs.html](http://www.dofmaster.com/dofjs.html)

ture number) results in less depth of field. Both sharpness and blurring are important aspects in design. Because of this, many single-lens reflex (SLR) cameras feature a depth of field preview button,

which can be used to visually check the appearance of the depth of field at various aperture settings before shooting the photograph. Last by not least, the focal length of the lens usually affects the depth



of field. Wide-angle lenses can achieve a greater depth of field compared to telephoto lenses. However, this is effective only if the camera remains at the same distance from the object. If the magnification ratio is the measure of things, as in closeup photography, the focal length has no influence on the depth of field when given the same magnification and aperture (see illustration on page 11). If you want to maintain the same image size with a different focal length, you need to change the distance from the object. In the closeup range, this will completely offset the influence of the change in focal length. If the distance from the object remains constant, the depth of field will change with different focal lengths. The magnification ratio and area shown in the image will also change, which means a larger portion of the view will be shown in the photograph. The object will be displayed as either larger or smaller on the film or sensor, depending on the focal length of the lens.

*Top: 300mm telephoto macro lens; 1/250 sec at f/5.6. Despite the shallow depth of field the camera can be handheld in a crunch.*

*Middle: 1/90 sec at f/9.5.*

*Bottom: 1/15 sec at f/19. Not possible without a tripod.*

### Relation of focal length, depth of field, and distance to object

Focal length	aperture	depth of field	distance to object	approx. magnification	film plane
150 mm	8	5,8 mm	80 cm	1:3	10,8 x 7,2 cm
100 mm	8	5,8 mm	53 cm	1:3	10,8 x 7,2 cm
50 mm	8	5,8 mm	27 cm	1:3	10,8 x 7,2 cm

Focal length	aperture	depth of field	distance to object	approx. magnification	film plane
150 mm	8	1,0 mm	60 cm	1:1	3,6 x 2,4 cm
100 mm	8	8,3 mm	60 cm	1:4	13,3 x 8,8 cm
50 mm	8	5,1 cm	60 cm	1:10	36 x 24 cm

Calculated with: Depth of Field, magnification ratio, and macro lens calculator, values rounded. <http://www.erik-krause.de/schaerfe.htm>  
For your own calculations you can find a depth of field calculator at [www.dofmaster.com/dofjs.html](http://www.dofmaster.com/dofjs.html)

### Camera Format

Smaller formats (such as the 1/2.5" sensors), which are found in digital compact cameras, can provide a larger depth of field in comparison to the smaller depth of field obtained by the significantly larger sensors of digital single-lens reflex (DSLR) cameras, and in small format film. This is due to the fact that in order to fill the frame with an object in various formats, you need to use a different magnification ratio, which results in a different depth of field. A magnification ratio of 1:2 can be used to fill an 18mm wide sensor with the image of a beetle that is 36mm long. As a result, an aperture of 8 will give a depth of field of 2.4mm. To fully show the same beetle on

small format film (36mm), a magnification ratio of 1:1 is required, which results in a smaller depth of field. In this case, an aperture of 8 results in a depth of field of 0.96mm.

### Aperture and Diffraction

Since the depth of field can shrink to a fraction of a millimeter with an increase in magnification, you may be tempted to correct this problem by stopping down the aperture to its technical limit. This makes sense up to a certain point. When going beyond this limit, there is a general loss of sharpness due to the bending of light rays on the diaphragm opening. This effect is called diffraction. While diffraction is also

present when the aperture is wide open, it is negligible since most rays of light will pass through the rather large shutter opening in a straight line.

### Aperture and Diffraction

Magnification ratio	minimum working aperture
1:2	32
1:1	22
2:1	16
3:1	11
4:1	8
5:1	5,6

▲ *Stopping down beyond the minimum working aperture leads to a loss of sharpness due to the diffraction of light on the edge of the diaphragm opening.*

### Shutter Speeds

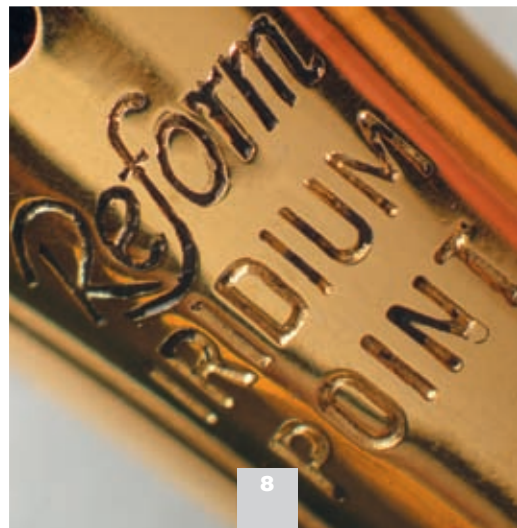
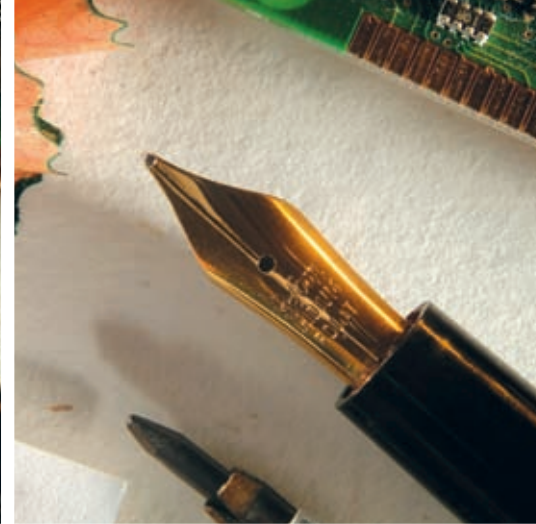
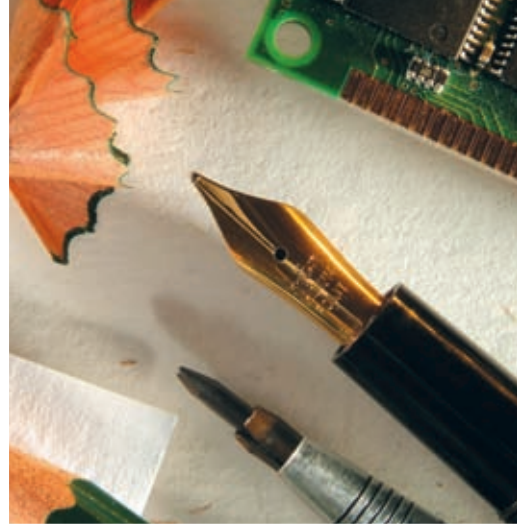
When the aperture is stopped down shutter speeds will increase. The same amount of light now needs more time to pass through a smaller shutter opening. As you advance further into the closeup range, more challenges are created with the extension of the lens, causing an additional loss of light. You can observe this phenomenon if you set your camera to aperture priority mode, and while keeping the same aperture, focus on an

object at different distances within the closeup range. The shutter speed displayed in the viewfinder will get longer the closer you get to the object. Because of the resulting loss of light due to both stopping down and lens extension, you will quickly reach the point at which your shutter speeds will become too slow to hand-hold the camera, making camera shake inevitable. In order to reach acceptable shutter speeds you have two options. One solution is to change the lighting situation by adding more light e.g., with reflectors or with a flash. Alternatively, you can change the light sensitivity by increasing the ISO value. However, increasing the ISO degrades the image quality as the image becomes grainier, and shows more noise. Lastly, you can mount the camera on a tripod in order to work with longer exposures. Use of a tripod is the optimal solution when a stationary object is being photographed, thus eliminating the possibility that the picture will show motion blur.



▲ *Calocoris quadripunctatus*.  
1/60 sec at f/9.5; 105mm macro  
lens; flash with softbox.

*We may meet bizarre creatures  
which appear as if they are from  
another planet.*



# Extreme Closeup

A true macro lens can range from a magnification ratio of 1:1 to the magnification ratio achieved when the lens is focused at infinity, while yielding high quality images without any optical aids.

The depth of field decreases significantly with an increase in magnification. Decent quality images beyond 1:1 can only be achieved with an SLR camera and specialty equipment.

*Standard zoom lens  
with macro mode at  
70mm\**

*Standard zoom lens  
with macro mode at  
70mm\*, close-up lens  
+2 diopters*

*50mm standard lens\*  
with 12 mm extension  
tube*

*Standard zoom lens  
with macro mode at  
70mm\*, close-up lens  
+10 diopters*

*Macro lens 105mm,  
magnification ratio 1:1*

*Macro lens 105mm,  
close-up lens +4 diopters*

*Macro lens 50mm with 2  
x converter, magnificati-  
on ratio 2:1*

*90mm macro lens with  
bellows, maximum  
extension*

*35mm lens reversed  
with bellows, maximum  
extension*

*\*Depending on close focusing distance (i.e., the closeup functions of the lens), the magnification ratio that can be attained will vary.*



▲ *Snail on fall foliage. 1/60 sec at f/16; 105mm macro lens; TTL-controlled flash with softbox.*

*By using the softbox you apply a light source that is far larger than the object and therefore create a pleasant soft light.*