Understanding Depth Of Field, Aperture, and Shutter Speed

Supplement to Mastering the Nikon D7000

This supplemental information is intended for readers of *Mastering the Nikon 7000* only. Please do not distribute this extra material to anyone other than a legitimate owner of the book. *Mastering the Nikon D7000* is available at the following website: **http://www.rockynook.com/book/203/mastering-the-nikon-d7000.html**

Understanding Depth of Field

Depth of field is one of those things that confuse a lot of new DSLR users. Yet, it is very important! I'm going to attempt to explain this concept using pictures. This topic transcends the actual DSLR being used. In fact, my illustrations were created with my trusty old Nikon D2X.

Let's say you are taking a picture of a friend who is standing 6 feet (2m) away from you. About 6 feet behind your friend is another person. There's also a third person standing about 6 feet behind the second person. Three people total, each about 6 feet apart, with the friend in front (see FIG 1A).

You are shooting with a 50mm f/1.8 lens. You focus on your friend's face, the young lady in red, and take a picture. It looks like the image in FIG 1A.

FIG 1A – Three kids at f/1.8, shutter speed at 1/6000

F/1.8 is an aperture number. An aperture is simply an opening in the front of your lens controlled by blades. It lets light come in through the lens to expose your D7000's sensor. You can't see the aperture when you look in the front of your lens (usually) since your D7000 allows you to focus with the aperture blades wide open and out of the way.

The aperture closes down to its selected setting when you press the Shutter–release button to take your picture, or when you press the Depth-of-field preview button. That's why the viewfinder often gets darker when you press the Depth-of-field preview button on your camera.

Apertures on your zoom lens probably start at about f/3.5 (big aperture), and stop at f/22 (small aperture). The bigger the aperture can get (the larger the opening) the faster the lens is considered. A fast lens is a lens with a big maximum aperture opening. The 50mm f/1.8 lens is a fast lens.

Notice that in FIG 1A your friend (in red) is in sharp focus. The girl standing behind her, to the right, is not in focus, nor is the young lad even farther away to the left. This is the result of shooting with a big aperture. F/1.8 is a big opening in the front of your lens. It causes the depth of field, or "zone of sharp focus", to be shallow. Only the girl in front is in focus at f/1.8. Not much else is in focus, so there is very little depth of field. The depth of field in this picture is much less than 3 feet (.91m) deep; it's probably more like 1.5 feet (.45m).

So what would happen if we closed the aperture down (stopped down) to a medium aperture like f/8? FIG 1B shows what that will do to the depth of field.

FIG 1B – Three kids at f/8, shutter speed at 1/500

Remember, you are focused on the girl in front, and at f/1.8 (a big, fast aperture) the others were out of focus. Without changing your focus in any way, you adjusted your aperture to f/8. Something changed!

You focused your camera on the girl in front, but now the girl to the right is sharp too, even though you did not change your focus control. The depth of field (zone of sharp focus) now extends past the girl in front and covers the girl in back. It got deeper.

However, also notice that the boy to the left is still not in focus. The background is not in focus either. The depth of field is deeper, but still not deep enough to cover all your subjects.

This image is the result of a medium aperture opening (f/8), not fast (f/1.8), and not slow (f/22). Now, let's consider what happens if we stop down, or close the aperture to a small opening like f/22 (see FIG 1C).

FIG 1C – Three kids at f/22, shutter speed at 1/40

Aha! Now everything in the picture is sharp. An aperture as slow and small as f/22 makes it easy to get sharp focus. Remember, you focused on the girl in front in all these pictures. At first, only the girl in red was in focus (f/1.8), and as the aperture got smaller (see FIG 2), more and more of the surroundings came into sharp focus (f/8 and f/22). We'll examine the aperture in the next section.

So, depth of field is simply the zone of sharp focus. It extends in front of and behind your focused subject, and gets deeper in both directions, toward the camera and away from it, as you stop down your lens. If you set your camera to Aperture priority auto (or Manual mode), you can adjust the aperture to control what is in focus in your pictures.

Don't forget that in this case you are also making trade-offs. All three images were shot at ISO 100, and once I started using the smaller apertures, the camera needed to compensate by using longer exposure times. The f/1.8 shot was at 1/6000 second. The f/8 shot was at 1/500 second. The f/22 final image required an exposure of merely 1/40 second.

This was fairly easy to pull off under sunny skies with stationary subjects, but you can see where the shutter speed exposure compensations could get troublesome if these three subjects were playing ball or jumping around. This is when the experienced photographer takes advantage of Manual mode.

Understanding Aperture and Shutter Speed

The Nikon D300(S) allows you to take excellent pictures without understanding how the aperture and shutter speed works, or what a focal length is. Why, then, have I included a chapter section devoted to that subject?

Many D7000 owners are interested in going beyond basic photography. Previously, they might have been using a camera with fewer features, or even a point and shoot model. The D7000 is a semi-professional camera, in that it provides a much finer degree of control over the final look of the image, and is robustly built. Many professionals use the Nikon D7000 as a "carry camera" for when they want to go out and shoot for fun, or even as a backup camera in case their main pro-level camera develops a problem.

Since many need just a little help with how these most basic of camera and lens functions work, I decided to include this chapter. Even if you feel that you understand the concepts well enough, why not do a quick review. Maybe you'll learn something helpful!

The relationship between the aperture and shutter speed seems to be a difficult thing to understand for quite a few photographers. Yet, it is one of the most important concepts to have knowledge of, since it affects how an image looks in a major way.

In this chapter, we'll look at the aperture and shutter speed settings in a comprehensive way. Then, we'll explore how the relationship between the two settings changes the appearance of an image. Finally, we'll consider how the various focal lengths of your lenses will affect your choice of lens.

Understanding the Camera's Aperture

You've probably read about or seen what's called a pinhole camera. A few years back many people liked to experiment with them for fun and education. All one needed was a box or tube, a piece of film, and a pinhole to use instead of a lens.

The concept involves fastening a piece of film on an inside wall of a light-tight box, and pricking a tiny pinhole in the opposite wall of the box. This will later allow light to shine through the pinhole onto the film on the opposite side. To use the pinhole camera you temporarily cover the pinhole, take the box out

into the sunlight, place it in front of an interesting scene, uncover the pinhole, and leave for while.

When you return, you cover the pinhole, go into a darkroom, cut the box open, and develop the film. If your pinhole was the right size for the amount of time the light was shining on the film through the pinhole, then you'll have a nice image taken in a very basic way. If you guessed wrong about the amount of time you let the light shine through the pinhole onto the film, the image will be either over or underexposed.

It seems a lot easier to use your D7000 instead of a pinhole camera, doesn't it? While it might be fun to use a pinhole camera a few times, it certainly wouldn't allow you to take the wide range of beautiful images you've been getting from your complex digital camera. However, the D7000 works in a similar way to the basic pinhole camera. The difference is variability. You can vary the size of the "pinhole" with the D7000.

With the pinhole camera, if you wanted to leave the box out in the sun for a longer period, you'd make a very small pinhole, so only a little light shines on the film. If you wanted to leave the box out in the sun for a shorter period, you'd make the pinhole bigger so that more light would hit the film.

That's the concept of an aperture, a variably-sized pinhole. Instead of a hole in a box with film taped to one wall, you have a light-tight camera "box" with a lens having aperture blades that allow you to vary the size of the pinhole. Instead of shining light on a piece film you have a digital sensor.

On the next page is a sample of six lenses with the shutter blades set to various aperture sizes (see FIG 2).

We are looking at the business end of the lens, which would normally be pointed at the subject:

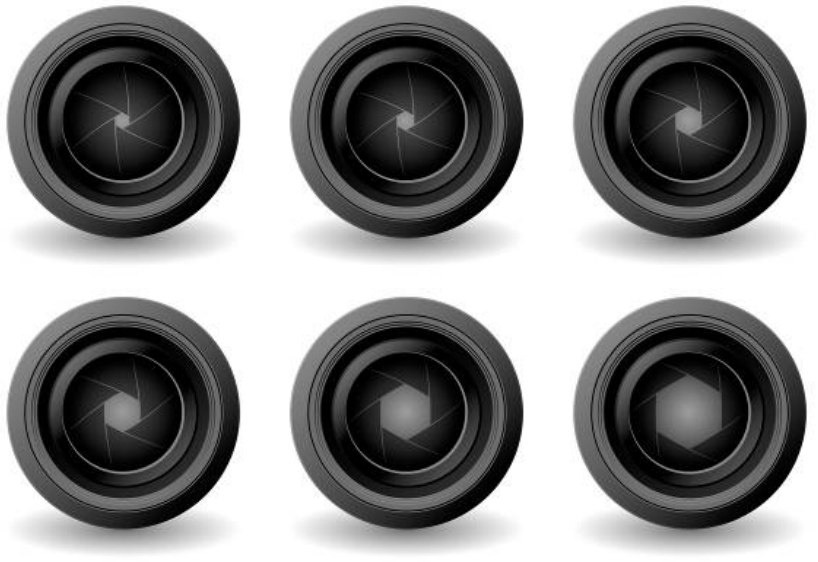

FIG 2 – Various aperture sizes seen while looking in the front of a lens

If you look at the front of your lens, with the lens cap off, you'll see the actual maximum aperture of your camera. Hold your D7000 so that you can look from the front of your lens from about half an arm's length away. Make sure that something bright is behind the eyepiece on the back of the camera. You can actually see through the front of your lens, right through the rear eyepiece of the camera. It's sort of like the time you looked through a pair of binoculars backwards when you were a child. Everything was small and distant, but you could see things.

The hole you see behind the glass of the lens is the biggest aperture, or largest pinhole, your D7000 can use with the particular lens mounted on the camera. Basically, the hole in the lens is your camera's "aperture."

Using the Aperture and Shutter Speed Together for Great Pictures

While the camera's *aperture* is concerned with ***how much*** light gets to the image sensor, the *shutter speed* is concerned with ***how long*** the light shines on the sensor.

In upcoming FIG 4, we see a test image with three exposures of the same subject. The first exposure is underexposed (too dark), the second exposure is just right, and the third exposure is overexposed (too light).

You must understand how to control both depth of field (aperture) and subject *movement* (shutter speed) in your pictures. Which is most important? That varies with the type of subject you are shooting.

FIG 3 - Flying bird stopped with fast shutter speed.

Let's say you are taking a picture of a bird flying through the air (see FIG 3). Of course, you want the bird to have a good focus covering its eye, body, and both wings, if possible. You need enough depth of field to be able to focus on the bird's eye, and still get the rest of him in the zone of sharp focus. You could set a small aperture, which you know will give you a nice deep depth of field so that all the bird is in focus.

However, when you use a small aperture for deep depth of field, the opening the aperture blades form is rather small, and not much light gets into the camera. So, to compensate you'll need to let the light come in for a longer time period, which means using a slower shutter speed. Unfortunately, a slow shutter speed means the bird will blur as it flies through the air. You've got yourself a real quandary!

How can you balance your need for stopping action (a fast shutter speed), with your need to keep all parts of your subject in focus (a small aperture)? Great question! Let's find an answer.

Now, let's say you are taking a picture of a beautiful scenic view of the mountains. You need deep depth of field to cover the distance from up close, to out past the mountain ridges, which requires using a small aperture. You also want to keep the wind from blowing the tree limbs and blurring them, so you want a faster shutter speed.

This quandary is what makes photography a learned skill. We are always balancing our need for depth of field, with our need to stop motion. When there's a lot of light, like on a bright sunny day, there may be enough light to have a small aperture and a fast shutter speed, which gives us deep depth of field and stop motion capability. However, if there is less light on our subject, we can't have both.

We can artificially make our cameras more sensitive to light by raising the ISO sensitivity of the sensor. In the old days we called it "film speed." That can be helpful, but when we take our camera much above the native ISO sensitivity (200), we start introducing digital artifacts called noise into our picture. We had the same results with very high speed films, and we called it "grain." High ISO sensitivity can create so much noise that our image is no longer very nice. So, higher ISO sensitivity is only used in an emergency when the shot must be acquired at all costs.

What we have to learn to do is to balance our shutter speed and aperture according to the most important thing we are trying to accomplish. What do you think is more important in our flying bird example (see FIG 3), mentioned previously? Should every part of the bird be in critical focus—or do we want to stop the motion of the bird flying through the air? Clearly, if the bird is blurry from movement it doesn't matter if we have good focus and depth of field, does it? So, in the bird example the most important thing is a fast shutter speed. We have to use whatever shutter speed will stop the bird's movement, even if we have to sacrifice some of our depth of field. In other words, we'll need to open the aperture to let enough light in so that we can limit the time the light comes in. We need a fast shutter speed, since that limits the time and can stop action.

In our mountain scene example, the mountain is not moving very fast, is it? So, the most important thing in that picture is that we have as much depth of field as possible. We want everything from the foreground all the way out to the far distance to be in good focus. We have to use a small aperture for depth of field—letting in less light—which means our shutter speed must be slower to let the light come in longer. We still desire a shutter speed fast enough to keep the limbs from blowing, but that's not as important overall as the deep depth of field.

In order to enjoy our pictures, they must be exposed properly in the first place. So, we'll have to learn how to balance aperture and shutter speed to get a proper exposure, while still capturing the image in the best way for the subject.

Let's discuss how a correct exposure is made by using a combination of aperture and shutter speed. We'll use an ***imaginary*** amount of light called "units." In FIG 4, we see a picture that takes 10 units of light to properly expose our subject. The picture with 10 units is correctly exposed, while the other two are not. How can we get a good "10 unit" exposure and make sure we have good depth of field and subject movement control?

FIG 4 - Imaginary Units of Light

We put our camera in Manual exposure mode, and focus on the scene above. The light meter reports that to get 10 units of light we need a shutter speed of 1/500s at an aperture of f/2. Now think about this a minute. At f/2, a big aperture, we will have very little depth of field. For sure, the limbs blowing in the wind will be stopped since the shutter speed is so fast at 1/500s, but the depth of field will be so shallow that our mountains in the distance will not be in focus.

Let me show you a series of exposure amounts that all give us exactly 10 of our imaginary "units" of light.

Exposure amount 1:	1/500s at f/2
Exposure amount 2:	1/125s at f/4
Exposure amount 3:	1/30s at f/8
Exposure amount 4:	1/8s at f/16

Our light meter tells us that at our current setting (1/500s at f2) gives us a good exposure, but we want more depth of field for a good distant focus. What can we do? We can select one of the other Exposure amounts in our list with a better aperture for our needs.

Which is best? Well, Exposure amount 1 (aperture f/2) will not work, since the depth of field is too shallow. Exposure amount 2 (aperture f/4) is better but only marginally so. Exposure amount 3 (aperture f/8) is getting much better, but since our distance is so great, still may not provide deep enough depth of field to reach all the way out to infinity while keeping the foreground sharp, too.

It looks like our solution is to use Exposure amount 4 (aperture f/16), which gives us a good aperture for deep depth of field, and should cover our scene well. However, the shutter speed is so slow at 1/8th of a second that we will blur the image from camera movement if we try to hand hold the camera while taking the picture.

What's our solution?

1. Go ahead and use Exposure amount 3 (aperture f/8), since it provides good depth of field. However, at 1/30th of a second it's hard to get a sharp image due to camera shake, so you'll have to be very careful and brace yourself, or
2. Put your camera on a tripod and use the best value—Exposure amount 4, (aperture f/16)—to keep the image sharp from foreground to distant mountains. It is nearly impossible to get a sharp image at a shutter speed of 1/8th of a second, so we must use a tripod at speeds this slow!

The whole point of inventing this imaginary "10 units of light" exposure system is to show you that you can arrive at a correct exposure using combinations of different aperture and shutter speed settings. In the real world, there are no "units" of light, just a correct or incorrect exposure. Our imaginary "10 units of light" simply represents a correct exposure.

1/30s at f/8 gives the image a correct exposure. 1/8s at f/16 provides exactly the same amount of light for a great exposure. 1/8s at f/16 is best for the mountain scene because the f/16 aperture gives so much depth of field and deep focus from foreground to infinity.

A Little More Exposure Detail

Let's play with our exposure amounts for a bit until this makes sense. I'll explain why 1/30s at f/8 and 1/8s at f/16 are exactly the same amount of exposure, and why either one will give a "10 unit" well-exposed picture, like in FIG 4. Here's why I used the imaginary units of light—to represent how light or exposure is cut in half or doubled by either the aperture or shutter speed.

If 1/125s at f/8 lets in 10 units of light, how many units would 1/125s at f/11 let in?

Remember, when the aperture number gets bigger, the aperture opening gets smaller. Since f/11 is one half the aperture size of f/8, it will only let in one half as much light.

1/125s at f/11 would then only give us 5 units of light—or half of what's needed—and our exposure would be dark, like in FIG 4's underexposed "5 Unit" picture.

> 1/125s at f/8 = 10 Units
> 1/125s at f/11 = 5 Units (aperture is half the size, so lets in half as much light)

The exposure above uses the same shutter speed, but the second exposure has an aperture half the size, and only lets in 5 units or half as much light. How can we compensate so that we get back to 10 units of light, without changing our aperture? We'll have to change the shutter speed, too! Since we've cut our light in half by using a smaller aperture opening, what would happen if we held the smaller aperture open for twice as long?

Aha! Holding the half-sized f/11 aperture open for twice as long—1/60th of a second—gives us exactly the same amount of light as an aperture opening of f/8 at 1/125th of a second. 1/60th of a second is twice as much time as 1/125th of a second. So, 1/60s at f/11 is half the light let into the camera for double the time; an equivalent exposure.

> 1/125s at f/8 = 10 Units
> 1/60s at f/11 = 10 Units (aperture half sized, shutter speed twice the time)

In other words—we've changed it so that our shutter speed is twice as long. Why? Since the aperture is half the size, we must allow more time for the light to come into the camera, by increasing the length of time the shutter is open. We double the time the shutter is open, putting light through the half-sized f/11 aperture for twice as long. That gives us our imaginary 10 units of light, for a correct exposure.

General Shutter Speed/Aperture Exposure Rule

To arrive at a similar exposure equivalency you have to first use the light meter to get a correct exposure reading. Then you think about what the aperture/shutter speed combination will give you. Do you need a faster shutter speed to control motion? Do you need a smaller aperture to have more depth of field?

Only you can make those decisions. The camera just suggests a combination that will give you a correct exposure, nothing more—unless you are using Auto exposure mode or one of the Scene modes—which makes the camera decide for you.

Here's a general rule for those using exposure modes A, S, or M (on Mode dial):

1. Get an accurate meter reading. (Use the camera's histogram readout too.)

2. Decide whether you need an aperture or shutter speed that differs from what the meter recommends. You might want more or less depth of field (aperture), or want to stop or blur motion (shutter speed).

3. Let's say the camera suggested 1/125s at f/8 for a good exposure, but you want a faster shutter speed to stop action. If you select a shutter speed one step faster, or 1/250s, which cuts the exposure to the sensor by half, you must open the aperture to let in more light. In other words, if you set the shutter speed one step higher (removes light), you'll need to open the aperture one step larger too (adds light). So if your original exposure was 1/125s at f/8, and you select 1/250s instead, simply open the aperture to f/5.6, and you get the same amount of exposure. In other words, by increasing your shutter speed by one step, you cut the time the light comes into the camera by half, so there is only half as much light that gets to the sensor. To compensate, you open the aperture to twice the previous size, so that ***twice as much*** light shines on the sensor. You have the exact same exposure with a different combination of aperture/shutter speed. 1/125s at f/8 equals 1/250s at f/5.6.

4. Likewise, if you wanted more depth of field than the metered amount of 1/125s at f/8 would allow, you could close the aperture to the smaller size of f/11 (stop down). The aperture f/11 lets in exactly half as much light as f/8. So, your exposure is exactly one half of the suggested good exposure. To compensate, you could use the slower shutter speed of 1/60s, which lets light in ***twice as long***. You are again giving the camera exactly the amount of light that it needs to make a good exposure, but have more depth of field. In other words, if you close the aperture by one step (removes light), you'll need to slow the shutter speed by one step (adds light). F/11 at 1/60s equals f/8 at 1/125s.

.

The two considerations are "how much," and "how long." Use your aperture to control *how much* light gets onto the sensor. Use your shutter speed to control *how long* the light gets to the sensor. Balance the two for a correct exposure!

Aperture and Shutter Speed Chart

In FIG 5 you'll find an Aperture & Shutter Speed Equivalency Chart for your use in figuring out how the relationships we've discussed above work, but in a more visual way.

f/stops	1.4	2	2.8	4	5.6	8	11	16	22
Equal Shutter Speeds Divisions of One Second	250	125	60	30	15	8	4	2	1 sec
	500	250	125	60	30	15	8	4	2
	1000	500	250	125	60	30	15	8	4
	2000	1000	500	250	125	60	30	15	8
	4000	2000	1000	500	250	125	60	30	15
	8000	4000	2000	1000	500	250	125	60	30

FIG 5 - Aperture and Shutter Speed Equivalency Chart

To use the chart you simply select a certain aperture and shutter speed combination. For instance, let's use 1/15s at f/5.6. Notice on the chart the orange-colored f/stops run from f/1.4 to f/22. Put your finger over on the f/5.6 position (5.6). Just below there you'll see the shutter speed of 1/15s (15). Put your finger on the shutter speed of 15. Move it to the left one space to 30 or 1/30s. You'll notice that above the 30 is an orange 4. The 4 represents f/4. Now this is important—f5.6 at 1/15s is ***exactly the same exposure*** as f/4 at 1/30s.

If you follow this out to the end of the chart, you'll see that f/5.6 at 1/15s is equal to f/8 at 1/8s. Also, f/11 at 1/4s is also equal to f/5.6 at 1/15s. Any of the numbers along the top (f/stops) of the chart matched with the number below (shutter speed) is exactly the same exposure. To make this clearer, I am going to list several exposures that are exactly the same, and bring the same amount of light into the camera:

- 1/250s at f/1.4
- 1/125s at f/2
- 1/60s at f/2.8
- 1/30s at f/4

As long as you keep your finger in the same row of shutter speeds, the aperture's above will give you an equivalent exposure. Let's switch to a new row of shutter speeds. Find the f/5.6 f/stop and look down the column until you find

1/125s (125). Using the same logic as before, here are more exposures that provide exactly the same amount of light to the camera's sensor:

- 1/125s at f/5.6
- 1/250s at f/4
- 1/500s at f/2.8
- 1/1000s at f/2

If you play with this chart for a while, you will begin to see how flexible your camera is in giving you so many choices of apertures and shutter speeds. Now you can choose just the right aperture for the best depth of Field in your image. Or, you can choose just the right shutter speed to stop action or allow blurred movement in your picture.

By using this chart and exercising your new knowledge while taking pictures, you'll soon become comfortable with the ideas expressed in this chapter. You'll have control of your camera in its manual modes, and much finer control over how your images "turn out." In fact, no one will be able to say, "*That one turned out well*." You'll be able to look at them and say, "*It didn't just turn out that way, I did it on purpose!*"