Topic 3 - A Closer Look At Exposure: Aperture

Learning Outcomes

In this lesson, we will revisit the concept of aperture and the role it plays in your photography and by the end of this lesson, you will have a much more advanced idea of how aperture can be changed or modified in its relationship with the two other exposure values, shutter speed and ISO.

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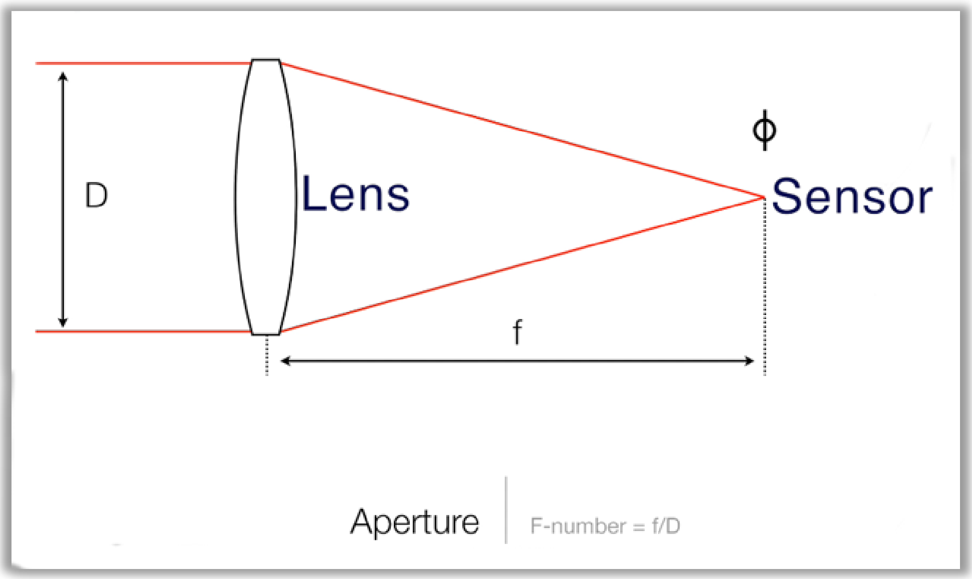
Aperture, at its maximum capacity, lets in as much light as it possibly can. Stopping it down, refers to the mechanism that lowers or changes the quantity of light that can enter the camera. Of course, with an SLR, you can modify how much light enters in through the lens, which is very useful for us as photographers.

We previously talked about stops for both ISO and shutter speeds, and we came across this idea that we halve or double the number. For example, we might have ISO 125 and one stop would move us up to ISO 250. This is where it gets a little trickier. Light enters this big circular region in the lens, and when we close that aperture, we can't actually halve that circle because we're dealing with area here. When we refer to the aperture, we are referring to the physical process of allowing light to enter the lens. When we refer to *f-stop* number, such as *f-2.8*, we're referring to the *f-number* rather than the aperture. The reason for this is because the f-number is a ratio.



Take a look at this simple diagram which reflects a lens and some light passing through it. Light is focused down and reflected onto the sensor, in the case of a DSLR. So, we have this lens, and it has this focal length, which we eluded to earlier.

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We know that a higher focal length means that you will be more zoomed in and a lower focal length will be less zoomed in.

The f-number relates to that focal length divided by the diameter of the aperture itself. This is the subtle difference between the two. The aperture is the physical size of the device that allows/ blocks light to enter the camera. On the other hand, the f-number is this ratio that deals with the focal length and the diameter itself.

Some Maths

Remember when I said that we have a little math to do? We're about to look at the bulk of it right now.

The $Area\ of\ a\ circle = \pi r^2$, which is a very basic geometrical equation. Each circle that we looked at has an area. In the smaller circle, in order to be a stop darker, or in order to let in half of the light, the smaller circle has to have half the area of the larger circle. To tie this back to the original problem, when we're dealing with the f-number, it is a ratio that handles the diameter and not the actual area. Due to the fact that we have a squaring of the radius, we have to work through a little bit of this math to figure out what's going on.

So, we have that area, but since we're talking about diameter, let's put this into something that is a little more familiar for some of us. When we have diameter, we have the entire width of that circle, whereas the radius is half that width, so in terms of area, the equation would be π times the diameter divided by 2^2. So, what we are trying to do, is to figure out how this diameter changes from $A1$ to $A2$, in order for this property to remain true. So, let us try and calculate the area of each.

The bigger circle has a diameter of $d1$ and the smaller circle has a dimeter of $d2$. So, if we want to calculate the area of each of these, we just plug the dimeter for each, into our equation.

$Area\ for\ (A1)\ is\ \pi\ (D/2)^2$

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We're just going to keep the diameter in terms of these variables so we can see how we can actually modify it. So, what we're saying is the diameter, or the area here, is π times the diameter, 1, of this first circle, divided by *2* squared. Now, we can simplify this when we realise that the bottom *2* can be squared and so we have an equation that looks something like this: $\pi d1^2$ all over *4.* In the second circle's case, we just change it to diameter *2*.

Now, we have the area of these two circles, and the point I would like to make is that the area of the bigger circle, is twice as big as the area of the smaller circle which would look something like this: *A1=A2 times 2*. And this lets in twice as much light. Now, I can input the area of these two circles, into our generalised equation to figure out the relationship between *d1* and *d2.* Ultimately, that is what we are trying to figure out.

So, we have $\pi d1^2 / 4 = 2$ *times* $\pi d2^2 \ / 4$. So, what will happen? Well, we must realise that there are some things that we can divide out to simplify this. So, divide both sides by pie over 4. As a result, we get $d1^2$ = *2 times* $d2^2$. Because both sides of the equation share *pie over 4*, they can just cancel out.

Now, we want to find out how much smaller *d2* is compared to *d1*. That means, that we have to divide both sides by *2* to get rid of this *2* on *d2's* side. Let's see what we have.

$d2^2$ = *½ times d1 squared.*

I can finally finish this up by taking the square root of each side.

Now, all I get is *d2* = to the *square root* of *½ times d1 squared.*

So far, this hasn't given us much extra information. We could further simplify this. We could go:

d2 = the square root of 2 over 2 times d1

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Now, you can really see what I meant when I said that it's not a nice doubling and halving, like what we have when dealing with shutter speed and ISO.

What does all of this math mean?

Well, if we take this and plug this into our initial ratio, this initial division, in which the f-number is actually the focal length divided by the diameter, this is pretty important. All we've done, up to this point, is figure out the difference in the diameter. So, what is one stop difference in terms of this f-number?

To make this as simple as possible, I'm going to make the focal length = 1. It's not realistic, but we're looking at this from a learning standpoint because all we want to figure out is what the difference is in one f stop to the other. So, let's look at the f number equation which is $F\ NUMEBR$ = FOCAL LENGTH divided by the DIAMETER. Again, to make it simpler, we will pick a focal length of one. Okay, so we are trying to start with an assumption that is, if we have an f number of 1 and let's say, that I have this lens here, which is the bigger one and so it is very bright, and it has a focal length of one and it also has a diameter of one, which makes it pretty simple. What will the f number be for this lens? Yes, the answer is one. Because it's just the focal length, which is one, divided by the diameter, which is also one. So, we are saying that the f number of this initial circle is, in fact, the value one. Because we've figured out how much smaller $d2$ is, which is the smaller circle, we can figure out the f number for $d2$. However, this f number will be one stop away because it is, half the size of the bigger circle.

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Now, when we go back to the equation, we can apply the number *1* to *d1* because we've figured out, that for this particular lens, the diameter and focal length is 1. So, the diameter of the smaller circle should be:

The square root of 2 divided by 2

We're plugging this into our equation to figure out what the f number is for our smaller circle. Let's do the math:

So, **1 divided by the square root of 2 over 2** is = to **2 over the square root 2** and we simply have answer of root 2. When you plug this into a calculator, this has a value of *1.4.* This f number of the smaller circle, which is a stop darker than the larger circle, is an f number of *1.4.* This is fundamental reason why f numbers are the way they are. The smaller circle has an area that is half as big as the larger circle but the f number doesn't change by *2,* as a result of this diameter, it actually changes by *1.4.* We can apply this over and over again to figure out what the next f number is going to be.

There is a way in which we can figure out the subsequent f numbers.

We have the first two numbers, *f 1* and *f 1.4* and all you have to do, is remember the these two because after this, all you have to do is multiply each one by *2*. So now, we have *2* and *2.8* and you simply just continue on, doubling these numbers. This moves on to *4* and *5.6.* You'll see these numbers becoming more familiar to you because this is what you'll have seen on your camera and you'll recall me mentioning shooting a picture at, let's say *f stop 2.8*.

Each of these are one stop apart and the bigger the number gets, as a result of this ratio, the darker the picture will get, because the shutter is getting smaller and smaller. We can also get thirds in between these stops, so *1* might go to *1.2* and then *1.3* before coming up to *1.4*. After *1.4* then, we might typically have *1.6* and *1.8* before getting to *2* and so on and so forth. They are simply thirds of a stop.

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That is really the finer details of how aperture works and this math could be used, if you really fancied the idea of creating your own pinhole camera. Feel free to explore this if you have been intrigued by all the maths in this lesson.

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What have we learned in this lesson? A Summary

We have learned more about the role of aperture in photography and how focal length, lens diameter and f stops are all interconnected. Specifically, we've looked at the math behind the numbers we see on our LCD screen that refer to our f stop numbers.

We have also learned about how important it is to remember the first two f stop numbers and how they continue to double after the first two.