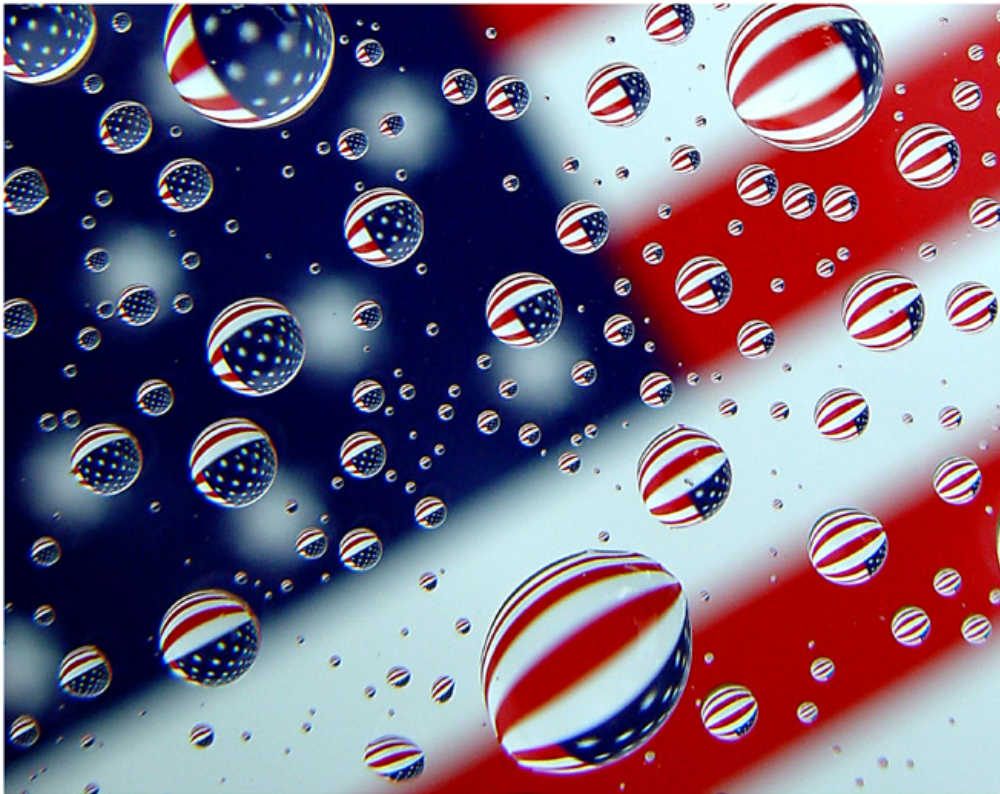


Exposure

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The Basic Elements of Exposure:

Exposure, in photographic terms, is the process of capturing light with your camera to produce an image on film or a digital sensor. (*Film and digital sensors will be referred to as film throughout this document unless specifically noted otherwise.*) Your camera mechanically controls the incoming light and directs it to the film. The film is sensitive to the light and is *exposed*.

We can create a simple analogy of exposure in terms of filling a bucket with water. We can fill the bucket slowly with a small stream of water, or we can fill it quickly with a large stream. In either situation, it will take a combination of time and water flow to fill the bucket. The size of the bucket is also a consideration. A small bucket will fill more quickly than a large one.

Based on this brief analogy, we have three items to consider. We have water flow, the amount of time it takes to fill the bucket, and the size of the bucket. We can approach our *Fill the Bucket* project from several angles. We can choose to use a larger or smaller hose. We can choose to fill the bucket quickly or slowly. We can choose the size of the bucket we want to fill. Whichever approach or combination of approaches we choose, the result will be the same. We will put water in our bucket. We may fill it completely full, partially full, or let it overflow.

How do we relate this analogy to our camera?

Light is the water that flows through our hose.

Our camera's *aperture* is the hose. The camera's aperture is the device that controls the amount of light that is allowed into the lens. This aperture is adjustable. We can make it larger or smaller.

Our camera's *shutter speed* is the amount of time it takes to fill the bucket with water. The camera's shutter is the device that opens to allow the incoming light from the aperture to expose the film and create the image.

The film's sensitivity or *ISO number* is the size of the bucket. Small buckets (more sensitive films) can be filled faster than large buckets (less sensitive films.)

The Four Elements:

So, we have four elements of exposure: light, aperture, shutter speed, and film sensitivity. Each of these elements plays a distinct role in the process of creating a photograph. Each of these elements may be used in creative ways.

Light:

Light is probably the most important element of exposure. In many cases, good and bad photos are only differentiated by the available light in the scene. Learning the difference between good and bad light is part of the overall experience of learning about photography. Light creates shadows, highlights textures, accents colors, creates moods and emotions, and a vast array of other enhancing effects in a photo. By the same token, light can also create harsh contrasts, bright spots, dark spots, glare, and other issues that are sometimes associated with poor photographs. Finding the good light is a skill that comes with experience and a lot of trial and error.

Aperture:

Your camera's aperture controls the amount of light that is allowed into the lens. The aperture is an adjustable hole inside your lens that may be made larger or smaller to control the intensity of the available light. The aperture is also used to control *depth of field*. Depth of field will be discussed in detail as we explore exposure a little deeper.

Shutter Speed:

The camera's shutter is the device that opens and closes for a specified amount of time to allow the light entering the lens to expose the film. The duration of the opening is determined by the amount of light entering the lens. The aperture and shutter work together to produce correct exposures.

Film Sensitivity (ISO):

Some films are more sensitive to light than others. The ISO rating of the film describes its sensitivity to light in numbers such as 25, 50, 100, 200, 400, and 800. 200 speed film is twice as sensitive to light as 100 speed and four times more sensitive than 50 speed film. 200 speed film will expose twice as fast as 100 and four times faster than 50. Different speeds of film are used for various reasons that we will discuss soon.

These four elements of exposure work together to produce a photograph. Light enters the camera through the aperture inside the lens. The shutter opens and then the film is exposed. In our quest to understand exposure, we must learn how each of these elements interacts with each other. We also must learn how to control each element to produce our desired result.

Important Terms to Remember:

Aperture – The aperture is the opening inside the lens of your camera that adjusts larger or smaller to control the amount of light that enters the lens.

Shutter – The shutter is the device inside the camera that opens and closes to allow the incoming light to expose the film.

ISO – The ISO rating of film describes its sensitivity to light. Higher numbers on this rating mean that the film is more sensitive to light and will expose faster than lower numbered ratings.

Understanding Stops:

The aperture and the shutter speeds on your camera are adjustable. Shutter speed adjustments are made in increments of seconds or fractions of a second. Aperture adjustments are made in units called *F-Stops*. Throughout this document, we will refer to adjustments in shutter speed and aperture in terms of *stops*.

Shutter Stops:

The following chart shows most of the standard shutter speeds in one-stop increments:

Shutter Stops
1/2000"
1/1000"
1/500"
1/250"
1/125"
1/60"
1/30"
1/15"
1/8"
1/4"
1/2"
1"

As you can see on this chart, each *stop* is approximately half or twice the speed of the adjacent stops on the scale. On this scale, 1" is the slowest shutter speed and 1/2000" is the fastest.

Aperture Stops:

Aperture adjustments are described in units of *F-Stops*. As we discussed earlier, the aperture is a *hole* that adjusts larger or smaller to control the amount of light that is allowed into the lens. To start this discussion, let's look at a chart of one-stop aperture increments:

Aperture F-Stops
f/2.0
f/2.8
f/4
f/5.6
f/8
f/11
f/16
f/22
f/32

When we look at this chart for the first time, it probably won't make much sense. The numbers here don't seem to have any real meaning. What this f -number represents is a ratio that describes the size of the aperture *hole*. This ratio actually describes the exact diameter of the hole. The f variable should be replaced with the focal length of the lens to calculate the diameter of the aperture. The following chart shows the diameter of the aperture opening on a 50mm lens:

Aperture F-Stop	50mm Lens Calculation	Aperture Diameter
f/2.0	50/2.0	25 mm
f/2.8	50/2.8	17.9 mm
f/4	50/4	12.5 mm
f/5.6	50/5.6	8.9 mm
f/8	50/8	6.25 mm
f/11	50/11	4.5 mm
f/16	50/16	3.125 mm
f/22	50/22	2.3 mm
f/32	50/32	1.56 mm

As you can see in this chart, f/2.0 is a much larger aperture size than f/32. When we look at the f -numbers, we must keep in mind that a smaller number represents a larger aperture. As the f -number increases, the size of the aperture hole decreases. Now, we need to take a look at another chart that shows why these particular numbers are chosen as *stops*.

Aperture F-Stop	50mm Calculation	Aperture Diameter	Aperture Area
f/2.0	50/2.0	25 mm	490 sq mm
f/2.8	50/2.8	17.9 mm	251 sq mm
f/4	50/4	12.5 mm	122 sq mm
f/5.6	50/5.6	8.9 mm	62 sq mm
f/8	50/8	6.25 mm	30 sq mm
f/11	50/11	4.5 mm	16 sq mm
f/16	50/16	3.125 mm	7.6 sq mm
f/22	50/22	2.3 mm	4.15 sq mm
f/32	50/32	1.56 mm	1.9 sq mm

The area of the aperture opening is where the *stops* are actually identified. If you look at the aperture area column of this chart, you can see that each change down the scale roughly changes the area of the opening by one half. This correlates with the shutter speed scale. Each change on the shutter speed scale was either one half or double the adjacent value. The same holds true with the aperture. One-stop variations are either half or double the adjacent aperture size.

It's not particularly important to know these calculations. What is important to know is the f-stop progression in one-stop increments. You need to know that increasing the *f*-number by one stop will reduce the area of the aperture opening by one half. By the same token, decreasing the *f*-number by one stop will double the area of the aperture opening. Increasing the size of the aperture by one stop allows twice as much light into the lens. Decreasing it by one stop reduces the incoming light by one half.

Correct Exposure Combinations:

When we choose an appropriate combination of shutter speed and aperture size for a particular photograph, it will not be the *only* combination that will work. There usually is a *best* choice, but we will discuss that later. There are multiple *correct* exposure combinations for any given scene.

A *correct exposure* is one where the photograph is not *overexposed* or *underexposed*. An overexposed photograph is one where we let too much light into the lens through the aperture and/or selected a shutter speed that was too slow. When this happens, the highlights (lighter colored areas of a photograph) are usually washed out and there is no detail visible in them. The darker areas of the photograph will also be too bright. An underexposed photograph is just the opposite. When we underexpose a photo, we did not allow enough light in through the aperture and/or we selected a shutter speed that was too fast. The darker areas of the photo are too dark and any detail that may have been visible in them is lost. The brighter areas of the image are also darker than they should be. In a correct exposure, the highlights are not too bright and the darker areas are not too dark. There is usually a nice balance between the lights and the darks.

Let's take a look at an example of a theoretical *correct* exposure setting on a camera.

Aperture: f/11
Shutter Speed: 1/250"
ISO: 100

There are several reasons, which we will discuss later, that we may not want to use this particular setting. Our objective with this example is to determine what our *correct* exposure options are based on this setting. There are a lot of possible options here. This example will also demonstrate why it is important to understand *stops*.

We can add a stop to the aperture, but in doing so, we must subtract a stop from the shutter or the ISO number. We can also add a stop to the shutter speed, but in doing so, we must subtract a stop from the aperture or the ISO. We have to maintain a balance if we want our exposure to be correct.

In our example, if we add a stop to the aperture (increase the size of the aperture by one stop), we would change the aperture setting to f/8. If we do this, we must maintain the balance by subtracting a stop from the shutter speed (increase the speed of the shutter) to 1/500". Increasing the size of the aperture allows more light into the lens. We must compensate by increasing the speed of the shutter to keep from overexposing the photograph.

Aperture: f/8
Shutter Speed: 1/500"
ISO: 100

These settings would also give us a correct exposure. The following chart displays a list of correct exposure values based on the original setting:

ISO	Aperture	Shutter Speed	
100	f/4	1/2000"	Also Correct
100	f/5.6	1/1000"	Also Correct
100	f/8	1/500"	Also Correct
100	f/11	1/250"	Initial Correct Value
100	f/16	1/125"	Also Correct
100	f/22	1/60"	Also Correct
100	f/32	1/30"	Also Correct

Any of these setting combinations will produce a correct exposure based on the original exposure value. As the aperture gets larger and allows more light into the lens, the shutter speed must get faster to keep from over exposing the image.

Important Terms to Remember:

Shutter Stop – a change in shutter speed that either doubles or halves the duration of the shutter opening time.

F-Stop – a change in the area of the aperture opening that either doubles or halves the area of the aperture opening, thus doubling or halving the amount of light that is allowed into the lens.

Stop – a generic term that describes an adjustment in exposure that is achieved either by increasing/decreasing the area of the aperture, increasing/decreasing the duration of the shutter, or a combination of both.

Correct Exposure – a shutter speed / aperture / ISO combination that does not create bright areas that are too bright and doesn't create dark areas that are too dark.

Overexposed – a shutter speed / aperture / ISO combination that makes the image overly bright and causes loss of detail in the brighter areas. The darker areas are also too bright.

Underexposed – a shutter speed / aperture / ISO combination that makes the image overly dark and causes loss of detail in the darker areas. The brighter areas of the photo are generally too dark as well.

Test Your Knowledge:

Stops and Exposure Combinations Question #1:

- a. How many *stops* are between f/2.0 and f/11?
- b. How many *stops* are between 1/125" and 1"?
- c. How many *stops* of sensitivity difference are there between ISO 100 and ISO 400 speed films?

Stops and Exposure Combinations Question #2:

We have the following correct exposure setting:

Aperture: f/5.6
Shutter Speed: 1/60"
ISO 100

Fill in the following chart for alternative correct exposure values:

ISO	Aperture	Shutter Speed	
100	f/2.0		Also Correct
100	f/2.8		Also Correct
100	f/4		Also Correct
100	f/5.6	1/60"	Correct Exposure
100	f/8		Also Correct
100	f/11		Also Correct
100	f/16		Also Correct

Stops and Exposure Combinations Question #3:

We have the following correct exposure setting:

Aperture: f/8
Shutter Speed: 1/125"
ISO 100

Fill in the following chart for alternative correct exposure values:

ISO	Aperture	Shutter Speed	
100		1/2000"	Also Correct
100		1/1000"	Also Correct
100		1/500"	Also Correct
100		1/250"	Also Correct
100	f/8	1/125"	Correct Exposure
100		1/60"	Also Correct
100		1/30"	Also Correct

You should be comfortable with these questions before you proceed. The remaining sections of this document require an understanding of manual exposure adjustments.

Stops and Exposure Combinations Question #4:

In the example shown in question #3, what change would we need to make if we wanted to shoot with an aperture of f/8 and a shutter speed of 1/500"?

Measuring the Light:

When we point our camera at any given scene, the camera must be able to measure the amount of available light. The aperture sizes and shutter speeds that we have already discussed are not just randomly selected to make an exposure. They are carefully chosen to produce a correct exposure. The process of measuring the incoming light for a proper exposure is called *metering*. Most modern cameras have a built-in meter that allows you to adjust your exposure to the proper level for any photo that you wish to take.

Metering Modes:

There are several different modes of metering. Most modern cameras have three different modes to choose from.

Evaluative Metering:

In the *evaluative metering* mode, your camera evaluates several points of light from various places within your image area. The meter will take an average of all these various readings and provide you with a correct exposure setting for the scene. I use the term *correct* very loosely when discussing evaluative metering because some scenes are difficult to meter correctly in this mode.

Center-Weighted Metering:

In the *center-weighted metering* mode, your camera evaluates the full area of your view, but it puts more *weight* on the center area when determining the proper exposure. Your viewfinder or LCD will generally show you the area being metered by providing a circle or a bracket display around that particular area.

Spot Metering:

In the *spot metering* mode, your camera takes a light reading from a very small *spot* in the center of the viewfinder. This spot is usually indicated by a dot or a crosshair in the viewfinder. It ignores everything else.

How to Use the Meter:

Learning to use your meter, regardless of the metering mode you choose, is important. As we discuss metering, we will be discussing in terms of fully manual exposure mode on your camera. Automatic and priority modes on your camera adjust your exposure for

you. We will be discussing manual adjustments only. We will also be working primarily with the spot meter mode. If you do not have spot meter mode available, you should use the center-weighted mode instead.

When you turn your camera on in manual exposure mode and pan your surroundings, you will see the meter readings change as the light in your scene changes. Your meter is evaluating the light and showing you where your correct exposure should be. Most meters show you a value between -2 and +2. These numbers indicate how many stops over or under the correct exposure you may be at any given time. Some cameras also show this information on a graph or a needle in a window. The objective is to set your exposure so that the reading is zero or the graph/needle indicates a setting in the center. This will indicate a correct exposure.

As your spot meter moves through areas of light and dark, you will see aggressive variations in the reading. The objective is to take a meter reading from a *neutral* area of the scene to set your exposure. To locate this *neutral* area, we need to divide our scene into three color areas. These areas will be black, gray, and white. Even though your scene is in color, the blacks, grays, and whites are the areas we want to consider when metering.

The reason for choosing these three areas is because of the way these colors naturally reflect light. Black doesn't reflect much light. It reflects approximately 9% of the light that is falling on it. White reflects much more. It reflects approximately 36% of the light that falls on it. Gray, however, is *neutral*. It reflects approximately 18% of the light that falls on it. Why is this important?

If we meter on black, our camera will detect less light than it should. If the camera detects a deficiency of light, it will cause you to overexpose your photograph if you follow the meter reading. If we meter on white, the camera will detect too much light and cause you to underexpose your photograph. If we meter on a gray area, the camera should allow you to calculate a correct exposure. Some scenes have no black, white, or gray to work with. In this case, it can be useful to have a *gray card*. Gray cards can be purchased at most camera shops and they are cheap. They are very useful to have for metering scenes where you are unsure of a good metering point. To use a gray card, you simply set it in your scene and move close with the camera and take a meter reading from the card. You should adjust your exposure based on the card reading.

You do not have to take your meter reading from your desired composition location with the camera. You can walk into your scene and take a close-up meter reading from any point. This is useful when you don't have spot meter capability as well.

Important Terms to Remember:

Metering – The process of evaluating the amount of light in your scene for the purpose of setting a correct exposure.

Evaluative Metering – Taking an average meter reading from multiple points in your scene.

Center-Weighted Metering – Taking an average meter reading from multiple points in your scene, but giving more weight to the values taken from the center area of the scene.

Spot Metering – Taking a meter reading from a specific point in your scene.

Gray Card – a gray-colored card that is calibrated to reflect 18% of the light that falls on it.

Test Your Knowledge:

Measuring the Light Question #1:

If you are photographing a scene that is predominantly white or predominantly black and don't have a gray card available, how would you take a meter reading and adjust your exposure?

Evaluating Your Options:

We have discussed how to calculate *correct* exposures. We have calculated alternative options for *correct* exposures. We have also discussed how to measure the light in a given scene. Now, it's time to associate some purpose with all of this.

When you approach a photo opportunity, there are several options that you should consider before you start shooting. In general, there are two primary questions you should resolve. Your photo will usually either depend on control over *depth of field* or *shutter speed* to produce the desired results. *Depth of field* describes how much of your scene is in sharp focus. Some photographs need everything to be in good focus and others depend on just a small portion of the image being in focus. *Shutter speed* will determine if the action in your photograph is stopped or if it is blurred.

Once you evaluate these options, you can begin to determine what choices you need for your *correct exposure*.

Aperture

As we discussed earlier, the aperture is the device inside the lens that opens and closes to control the amount of light that is allowed into the lens. Adjustments in the aperture are described in terms of f-stops. An interesting by product of changing the size of the aperture is that it changes the *depth of field* at the same time.

To understand what depth of field is, imagine your photographic scene as a three-dimensional cube. You are photographing an area of length, width, and height. The front surface of your cube begins at the lens surface of your camera and extends outward as far as your camera can see. Within this cube, a slice of it parallel to the lens surface will be in focus. The slice may be very thick, very thin, or somewhere in between. A deep depth of field would describe a very thick slice of your cube. A shallow depth of field would describe a very thin slice of this cube.

Your choice of aperture size will help determine how thick or thin your depth of field slice will be. Large aperture sizes create a more shallow depth of field. Smaller aperture sizes create a deeper depth of field. The thickness of your slice in focus will vary based on several items: aperture size, *focal length*, and distance to subject.

A large aperture size produces a more shallow depth of field. A long focal length makes it even more shallow. The closer your lens is to your subject makes it even more shallow.

A small aperture size produces a deeper depth of field. A short focal length makes it even deeper. The more distance between the camera and the subject makes it even deeper.

When planning a photograph where depth of field is a primary concern, you should perform your metering with this in mind. If you set your aperture for the desired size before you meter, you can simply adjust the shutter speed to create your correct exposure. This can also be performed in *aperture priority mode* if your camera supports that function. In aperture priority mode, you select your desired aperture and your camera will automatically select a correct shutter speed to go with it based on your meter reading.

Preparing for a Shallow Depth of Field:

A shallow depth of field will help you isolate your subject or some specific part of your subject in the photograph. Your objective is to focus on something and have the foreground/background outside of that specific area out of focus. In order to accomplish this, you should try to choose a desired aperture setting before you perform your metering.



The Bluesman © 2003 – [John M. Setzler, Jr.](http://www.setzler.net)
1/250" @ f/2.8 – ISO 100

In this photograph, I wanted to focus on the guitar player's left hand and bring it to the forefront of attention in the photo. I deliberately selected a large aperture and the longest focal length I had available for this shot. I focused on his hand in an effort to let the left side of this photo fade out of focus.



Eight Ball – Corner Pocket © [Langdon Oliver](#)
1/25" @ f/3.2 – ISO 100

Langdon created a shallow depth of field on this photo with a large aperture. The depth of field in this photo encompasses the cue ball only. The area in the foreground and in the background fade out of focus.

Preparing for a Deep Depth of Field:

A deep depth of field requires a smaller aperture setting. The purpose of creating a deep depth of field is to bring a majority, if not all, of your photograph into sharp focus. Smaller apertures, shorter focal lengths, and greater distance to your subject will all contribute to a deeper depth of field.



Bridge of Sighs © 2003 – [John M. Setzler, Jr.](http://www.setzler.net)
1/125" @ f/8.0 – ISO 100

This photograph uses a very small aperture to achieve sharp focus throughout the entire image. Everything here is in focus.

Considerations:

Having everything in your photograph in good sharp focus does NOT always require a deep depth of field. It is entirely possible to bring everything into sharp focus with aperture size that is larger than your smallest choice. Depending on your subject, you may be able to have everything in your photo in sharp focus with your largest available aperture setting.

Case 1:

In your three-dimensional environment, you should evaluate your composition by determining the overall depth of the scene. If you are photographing something like the face of a building, the overall depth of your subject is rather shallow to begin with. Large aperture settings will generally keep everything in focus. If you are photographing the face of a building at an angle that is not parallel to the face, your scene will be a bit deeper and may require a little smaller aperture to keep it in focus. In either case, it would not likely require your smallest aperture setting to keep it all in focus.

Case 2:

In your three-dimensional environment, you have subject elements that are close to the camera and others that are far away. This case will require a smaller aperture to make sure everything is in focus. It may not require the absolute smallest option.

Case 3:

Case 3 would fall into the *in-between* realm. Your subject and composition may involve some depth but may not require full depth of field for the scene. In a case like this, you could work with a mid-range aperture setting and perform a little trial and error *bracketing* of your exposure. Bracketing means that you shoot several photos with different settings. You start with your best guess and then shoot with a few aperture settings above and below your starting point.

There is a way to determine how much of your scene can be in sharp focus based on the lens focal length and the aperture setting...

Hyperfocal Distance:

The *hyperfocal distance* is the point in your composition where everything from half that distance to infinity is in focus. For instance, if the calculated hyperfocal distance is 25 feet, if you set the focus on your camera to 25 feet or focus on something that is 25 feet away from your camera, everything from 12.5 feet to infinity will be in focus.

$$\text{Hyperfocal Distance (ft)} = ((\text{FL} * \text{FL}) / (\text{Ap} * \text{CoC})) * 0.0033$$

FL = Lens Focal Length

Ap = Aperture F Number

CoC = Circle of Confusion size (0.02 is used for most digital cameras)

0.0033 = conversion from millimeters to feet

Example of this calculation with a 28mm lens at f/16:

$$\text{HFD} = ((28 * 28) / (16 * 0.02)) * 0.0033$$

$$\text{HFD} = ((784) / (0.32)) * 0.0033$$

$$\text{HFD} = 2450 * 0.0033$$

$$\text{HFD} = 8.08 \text{ feet}$$

In this example, if you set your focus at about 8 feet, everything from 4 feet to infinity will be in focus in your photo.

Taking advantage of the hyperfocal distance can help you out in several ways. When photographing wide-angle scenes where your objective is to have everything in sharp focus, you would normally use the smallest aperture possible for the photograph. The small aperture gives you the greatest depth of field. However, you may still have objects in your image that are out of focus or soft because they are close to the camera. The reason for this is that your point of focus is far away. When your focus is way out in the distance somewhere, your near focus distance is farther away as well, so closer objects in your scene may appear soft or out of focus.

Another advantage of using the hyperfocal distance is that you may be able to work with a larger aperture and faster shutter speed while keeping everything in your image in focus. In the above calculation example using 28mm and an aperture of f/16, let's assume that our shutter speed for proper exposure is 1/60". If you are shooting a landscape where there is a bit of a breeze, you could possibly get some motion blur on the tree leaves or in the grass at that shutter speed. If you could shoot the same scene at f/8 and a shutter speed of 1/250", you will greatly reduce the chances of blur in your image. Using the above calculation, our hyperfocal distance for 28mm at f/8 would be about 16.1 feet. This means that if we focus on something 16 feet out, we will have sharp focus from 8 feet to infinity. If there is nothing within our composition inside of 8 feet, we could change apertures, get a faster shutter speed, and still keep everything in focus.

Below is a hyperfocal distance / near focus distance chart for various focal lengths and aperture settings:

Focal Length (mm)	Near Focus Distance / Hyperfocal Distance (ft)									
15	13.26	26.52	10.31	20.63	9.28	18.56	6.63	13.26	5.30	10.61
17	17.03	34.06	13.25	26.49	11.92	23.84	8.52	17.03	6.81	13.62
20	23.57	47.14	18.33	36.67	16.50	33.00	11.79	23.57	9.43	18.86
24	33.94	67.89	26.40	52.90	23.76	47.52	16.97	33.94	13.58	27.15
28	46.20	92.40	35.93	71.87	32.34	64.68	23.10	46.20	18.48	36.96
30	53.04	106.07	41.25	82.50	37.13	74.25	26.52	53.04	21.21	42.43
35	72.19	144.38	56.15	112.29	50.53	101.06	36.09	72.19	28.88	57.75
40	94.29	188.57	73.33	146.67	66.00	132.00	47.14	94.29	37.71	75.43
45	119.33	238.66	92.81	185.63	83.53	167.06	59.67	119.33	47.73	95.46
50	147.32	294.64	114.58	229.17	103.13	206.25	73.66	147.32	58.93	117.86
Aperture	NFD	1.4	NFD	1.8	NFD	2	NFD	2.8	NFD	3.5

Focal Length (mm)	Near Focus Distance / Hyperfocal Distance (ft)									
15	4.64	9.28	4.13	8.25	3.31	6.63	2.32	4.64	1.69	3.38
17	5.96	11.92	5.30	10.60	4.26	8.52	2.98	5.96	2.17	4.34
20	8.25	16.50	7.33	14.67	5.89	11.79	4.13	8.25	3.00	6.00
24	11.88	23.76	10.56	21.12	8.49	16.97	5.94	11.88	4.32	8.64
28	16.17	32.34	14.37	28.75	11.55	23.10	8.09	16.17	5.88	11.76
30	18.56	37.13	16.50	33.00	13.26	26.52	9.28	18.56	6.75	13.50
35	25.27	50.53	22.46	44.92	18.05	36.09	12.63	25.27	9.19	18.38
40	33.00	66.00	29.33	58.67	23.57	47.14	16.50	33.00	12.00	24.00
45	41.77	83.53	37.13	74.25	28.93	59.67	20.88	41.77	15.19	30.38
50	51.96	103.13	45.83	91.67	36.83	73.66	25.78	51.56	18.75	37.50
Aperture	NFD	4	NFD	4.5	NFD	5.6	NFD	8	NFD	11

Focal Length (mm)	Near Focus Distance / Hyperfocal Distance (ft)									
15	1.16	2.32	0.84	1.69	0.69	1.38	0.58	1.16	0.41	0.83
17	1.49	2.98	1.08	2.17	0.88	1.77	0.75	1.49	0.53	1.06
20	2.06	4.13	1.50	3.00	1.22	2.44	1.03	2.06	0.73	1.47
24	2.97	5.94	2.16	4.32	1.76	3.52	1.49	2.97	1.06	2.11
28	4.04	8.09	2.94	5.88	2.40	4.79	2.02	4.04	1.44	2.87
30	4.64	9.28	3.38	6.75	2.75	5.50	2.32	4.64	1.65	3.30
35	6.32	12.63	4.59	9.19	3.74	7.49	3.16	6.32	2.25	4.49
40	8.25	16.50	6.00	12.00	4.89	9.78	4.13	8.25	2.93	5.87
45	10.44	20.88	7.59	15.19	6.19	12.38	5.22	10.44	3.71	7.43
50	12.89	25.78	9.38	18.75	7.64	15.28	6.45	12.89	4.58	9.17
Aperture	NFD	16	NFD	22	NFD	27	NFD	32	NFD	45

This chart can make a handy reference to carry in your camera bag.

Important Terms to Remember:

Depth of Field – Depth of field is the area in your three-dimensional photo scene that will be in sharp focus. This *slice* of your three-dimensional space will be parallel to the lens of your camera.

Focal Length – The distance between the film and the optical center of the lens when the lens is focused on infinity (measured in millimeters).

Aperture Priority Mode – Aperture priority mode on your camera allows you to specify an aperture setting while the camera automatically adjusts the shutter speed based on your aperture choice and its internal meter reading.

Bracketing – Bracketing is the process of creating exposures with settings above and below your initial setting. This is used when you are unsure of the correct or best setting for the photograph.

Hyperfocal Distance – The hyperfocal distance the point in your composition where everything from half that distance to infinity is in focus.

Near Focus Distance – The near focus distance is the point in your composition where sharp focus begins. It is one half of the hyperfocal distance.

Test Your Knowledge:

Aperture Question #1:

You have a lens that works in the aperture range of f/2.8 through f/22. On this lens, is f/4 a large or a small aperture opening?

Aperture Question #2:

On the same lens described in question #1, what aperture setting would give you the greatest depth of field?

Aperture Question #3:

On the same lens described in question #1, what aperture setting would give you the smallest depth of field?

Exercises:

Exercise 1:

Find an object such as a drinking glass or bottle to photograph. Take it outside and set it on a rail or a table. Setup your tripod and compose the first photograph using maximum zoom and maximum aperture size. Compose the photo in such a way that the subject does not fill the entire frame and some of the background is visible.

The resulting photo should have a relatively shallow depth of field. The subject should be in focus and the background should be blurry to some extent.

Without moving the tripod or changing the zoom, adjust your aperture to the next smaller size and take another photo. Repeat this process until you have 5 or 6 photos, each with a smaller aperture size.

When you examine these photos, the background should become less blurry with each smaller size aperture setting because the depth of field is increasing with each adjustment.

Exercise 2:

Find a landscape scene that has objects close to the camera and far away. Set your camera up on a tripod and compose your photograph. Set your aperture to the smallest setting possible and focus on the object that is the farthest away in the scene. Take a photo.

Take a second photo and set your focus on something that is at the hyperfocal distance for your particular lens and aperture setting.

Compare the two photos and see if the second photo has more sharpness in the foreground than the first photo does.

Shutter

The shutter is the *curtain* inside your camera that opens for a specified duration to allow the incoming light to expose your film or digital sensor. There are several reasons that you would want to take control of your shutter speed. One of the main points of interest when discussing shutter speed is knowing how fast of a shutter speed you need to safely hand hold the camera for photographs. In lower light situations, hand holding your camera can create blurry and unappealing photos. My own general rule of thumb is to use a tripod unless I can't for some reason. If I can't use a tripod, I try to steady myself against something solid when hand holding the camera. A good rule of thumb is that you will need a shutter speed of 1/60" or faster for decent hand held photos.

When you are evaluating a photo based on shutter speed, you will be considering motion blur or stopping the action. Creating motion blur requires slower shutter speeds while stopping the action requires faster speeds. When the shutter speed requirements for your shot are most important, you will take control of the shutter speed and use an aperture setting that accommodates your shutter speed choice.

Stopping the Action:

Fast shutter speeds are used to freeze motion. There are more situations than you may imagine where freezing the motion is beneficial. Sports photographers like to freeze the action in their photos, but landscape photographers do also. You won't generally consider freezing the motion in a landscape photo, but using a fast shutter speed will make a difference in many cases. A slight breeze in your landscape can create *motion blur* in trees and greenery that can cause your photo to appear unsharp in areas. Long telephoto shots also require a faster shutter speed to reduce motion blur and *camera shake*. The slightest vibrations or movement of your camera are significantly amplified when you are using a long zoom. When using a long telephoto lens, a good rule of thumb for a shutter speed selection to stop motion is 1/focal length. If you are using a 300mm lens zoomed out to 300mm, 1/300" or faster is a good minimum shutter speed for a hand held photo.

In my own photography where depth of field is not a primary concern, I always try to use the fastest shutter speed possible. This eliminates the possibility of any unwanted motion.



Dairy Queen © 2003 – [Danny Shaw](#)
1/500" @ f/7.0 – ISO 100

In this photo, Danny used some creative lighting and a fast shutter speed to capture a beautiful splash crown.



Got Till It's Gone © [Árni Torfason](#)
1/4000" @ f/5.6 – ISO 100

Arni has created a very nice stopped motion shot with the breaking glass of wine. The very fast shutter speed in this image has frozen a lot of very fast motion.

Creating Motion:

In some cases, you can add a lot of visual impact to a photo by creating motion blur. Longer shutter speeds are used to achieve this effect.

Long Exposures:

Mounting your camera on a tripod and using a long shutter speed is one primary method of creating a nice motion effect in your photograph. When your camera is mounted to a tripod, you can create blur on moving objects and keep all the still segments of your photo in nice sharp focus.



Stallions at the Speed of Light © 2003 – [John M. Setzler, Jr.](http://www.setzler.net)
1" @ f/8 – ISO 100

A 1" exposure on this carousel gives an impression that it is moving much faster than in reality.

Slight Blur:

You can also use the same technique to create slight blurs. The shutter speed is faster for these photos but still slow enough to capture some motion in the photograph.



Hat Trick © [Tim Jensen](#)
1/125" @ f/2.2 – ISO 100

Due to the speed of this moving dart, Tim was able to capture some interesting motion blur at 1/125".

Panning:

Panning is the process of following a moving subject with your camera and using a slightly slower shutter speed. Your moving subject will be more in focus while the surroundings that are normally still will be blurred.



Speed-Doo! © 2003 – [Danny Shaw](#)
1/125" @ f/5.6 – ISO 160

In this photo, Danny followed the jet ski with the camera and allowed the background to be blurred.

There are a lot of creative options that you can pursue by taking control of your shutter speed. This is definitely an area that you will want to experiment in.

Important Terms To Remember:

Shutter – The shutter is the device inside the camera that opens to allow the incoming light to expose the film.

Motion Blur – Motion blur is blur that exists in a photograph caused by an exposure length that is long enough to allow the subject to move while the shutter is open.

Camera Shake – Camera shake is an *anomaly* that causes motion blur. Camera shake is caused by the camera moving slightly during an exposure which creates blur in the photograph.

Panning – Panning is the process of following a moving subject with the camera. The objective is to have the subject sharp while the background and surrounding environment gets blurry and out of focus.

Test Your Knowledge:

Shutter Question #1:

You calculate a correct exposure of 1/250" @ f/5.6 for a particular scene. You want to create motion blur in this scene and 1/250" is generally too fast to create any noticeable motion blur. If your lens is capable of stopping down to f/22, what would be the slowest shutter speed you would have available for this photograph?

Shutter Question #2:

You calculate a correct exposure of 1/125" @ f/16 for a particular scene. You want to make sure that there is no motion blur visible in your photograph. Your lens is capable of a maximum aperture size of f/2.8. What would be the fastest shutter speed you would have available for this photograph?

Exercises:

Exercise 1:

Create 5 photographs of moving subjects while your camera is still and mounted on a tripod. Use a fast enough shutter speed where there is no motion blur. Your objective is to stop any motion by using a fast shutter.

Exercise 2:

Create 5 photographs of moving subjects while your camera is still and mounted on a tripod. Use a shutter speed where there is a slight amount of motion blur in your moving subjects. Your objective is to allow just a slight amount of motion blur.

Exercise 3:

Create 5 photographs of moving subjects while your camera is still and mounted on a tripod. Do this at dusk or after dark where you will be able to use a shutter speed of 1" or slower to achieve your shots. Your objective is to create a lot of motion blur.

Exercise 4:

Create 5 photographs of moving subjects by following the subject with your camera. Your objective is to have the subject in focus while the panning motion creates blur in the background and surrounding areas. 1/60" and slower are good speeds to work with for panning.

In Conclusion:

All of the material here can only help you learn how to control your photograph. What it can't do is tell you where to point the camera and when to press the button. The creative side of photography is something that you have to develop on your own.

Learning how to control your camera gives you more and better opportunities to produce great photographs. If you do not understand how the camera functions to create an image on film or a digital sensor, you will diminish your opportunities for great results. Using the techniques and information described here, over time, will help you *know* how your camera should be set up to achieve a desired result. You won't waste time guessing and wasting film or disk space with as many undesirable photographs.

Developing your photographic *eye* also takes time. Some people have this natural talent and others spend a lifetime trying to find it.

Appendix:

Glossary Of Terms:

Aperture – The aperture is the opening inside the lens of your camera that adjusts larger or smaller to control the amount of light that enters the lens.

Aperture Priority Mode – Aperture priority mode on your camera allows you to specify an aperture setting while the camera automatically adjusts the shutter speed based on your aperture choice and it's internal meter reading.

Bracketing – Bracketing is the process of creating exposures with settings above and below your initial setting. This is used when you are unsure of the correct or best setting for the photograph.

Camera Shake – Camera shake is an *anomaly* that causes motion blur. Camera shake is caused by the camera moving slightly during an exposure which creates blur in the photograph.

Center-Weighted Metering – Taking an average meter reading from multiple points in your scene, but giving more weight to the values taken from the center area of the scene.

Correct Exposure – a shutter speed / aperture / ISO combination that does not create bright areas that are too bright and doesn't create dark areas that are too dark.

Depth of Field – Depth of field is the area in your three-dimensional photo scene that will be in sharp focus. This *slice* of your three-dimensional space will be parallel to the lens of your camera.

Evaluative Metering – Taking an average meter reading from multiple points in your scene.

Focal Length – The distance between the film and the optical center of the lens when the lens is focused on infinity (measured in millimeters).

F-Stop – a change in the area of the aperture opening that either doubles or halves the area of the aperture opening, thus doubling or halving the amount of light that is allowed into the lens.

Gray Card – a gray-colored card that is calibrated to reflect 18% of the light that falls on it.

Hyperfocal Distance – The hyperfocal distance the point in your composition where everything from half that distance to infinity is in focus.

ISO – The ISO rating of film describes its sensitivity to light. Higher numbers on this rating mean that the film is more sensitive to light and will expose faster than lower numbered ratings.

Metering – The process of evaluating the amount of light in your scene for the purpose of setting a correct exposure.

Motion Blur – Motion blur is blur that exists in a photograph caused by an exposure length that is long enough to allow the subject to move while the shutter is open.

Near Focus Distance – The near focus distance is the point in your composition where sharp focus begins. It is one half of the hyperfocal distance.

Overexposed – a shutter speed / aperture / ISO combination that makes the image overly bright and causes loss of detail in the brighter areas. The darker areas are also too bright.

Panning – Panning is the process of following a moving subject with the camera. The objective is to have the subject sharp while the background and surrounding environment gets blurry and out of focus.

Shutter – The shutter is the device inside the camera that opens and closes to allow the incoming light to expose the film.

Shutter Stop – a change in shutter speed that either doubles or halves the duration of the shutter opening time.

Spot Metering – Taking a meter reading from a specific point in your scene.

Stop – a generic term that describes an adjustment in exposure that is achieved either by increasing/decreasing the area of the aperture, increasing/decreasing the duration of the shutter, or a combination of both.

Underexposed – a shutter speed / aperture / ISO combination that makes the image overly dark and causes loss of detail in the darker areas. The brighter areas of the photo are generally too dark as well.

Test Your Knowledge Answers:

Stops and Exposure Combinations Question #1:

- a. How many *stops* are between f/2.0 and f/11?

Answer: 5 stops

- b. How many *stops* are between 1/125" and 1"

Answer: 7 stops

- c. How many *stops* of sensitivity difference is there between ISO 100 and ISO 400 speed films?

Answer: 2 stops

Stops and Exposure Combinations Question #2:

We have the following correct exposure setting:

Aperture: f/5.6
Shutter Speed: 1/60"
ISO 100

Fill in the following chart for alternative correct exposure values:

ISO	Aperture	Shutter Speed	
100	f/2.0	1/500"	Also Correct
100	f/2.8	1/250"	Also Correct
100	f/4	1/125"	Also Correct
100	f/5.6	1/60"	Correct Exposure
100	f/8	1/30"	Also Correct
100	f/11	1/15"	Also Correct
100	f/16	1/8"	Also Correct

Stops and Exposure Combinations Question #3:

We have the following correct exposure setting:

Aperture: f/8
Shutter Speed: 1/125"
ISO 100

Fill in the following chart for alternative correct exposure values:

ISO	Aperture	Shutter Speed	
100	f/2.0	1/2000"	Also Correct
100	f/2.8	1/1000"	Also Correct
100	f/4	1/500"	Also Correct
100	f/5.6	1/250"	Also Correct
100	f/8	1/125"	Correct Exposure
100	f/11	1/60"	Also Correct
100	f/16	1/30"	Also Correct

Stops and Exposure Combinations Question #4:

In the example shown in question #3, what change would we need to make if we wanted to shoot with an aperture of f/8 and a shutter speed of 1/500"?

In order to do this, we would have to change over to ISO 400 film or adjust our ISO setting on our digital camera. Adjusting to a film sensitivity that is 4 times more sensitive would allow us to increase our shutter speed by two stops from 1/125" to 1/500".

Measuring the Light Question #1:

If you are photographing a scene that is predominantly white or predominantly black and don't have a gray card available, how would you take a meter reading and adjust your exposure?

This is a bit of a trick question. Remember that black reflects about 9% of the light that falls on it. White reflects about 36% of the light that falls on it. The calibrated gray card that we use for metering reflects 18% of the light that falls on it.

If your scene is predominantly black, your camera will not read the proper amount of incoming light. It's going to measure half as much light as it should. Therefore it will set an exposure that will overexpose your scene by approximately one stop. When you take a meter reading on a predominantly black scene or on a black subject, you will need to correct the exposure by one stop. You will either adjust the aperture to the next smaller stop size, or you will adjust your shutter speed to the next faster stop. Whatever meter reading you get, you need to underexpose that reading by one stop to get correct exposure.

If your scene is predominantly white, the opposite will occur. Your camera will read too much light because the white is reflecting twice as much light as it should. Your meter will set an exposure that is approximately one stop underexposed because of this. You will have to correct this exposure by overexposing the meter reading by one stop. You

can achieve this by adjusting the aperture to the next larger stop or by adjusting the shutter speed to the next slower stop.

Aperture Question #1:

You have a lens that works in the aperture range of f/2.8 through f/22. On this lens, is f/4 a large or a small aperture opening?

Answer: Large

Aperture Question #2:

On the same lens described in question #1, what aperture setting would give you the greatest depth of field?

Answer: f/22

Aperture Question #3:

On the same lens described in question #1, what aperture setting would give you the smallest depth of field?

Answer: f/2.8

Shutter Question #1:

You calculate a correct exposure of 1/250" @ f/5.6 for a particular scene. You want to create motion blur in this scene and 1/250" is generally too fast to create any noticeable motion blur. If your lens is capable of stopping down to f/22, what would be the slowest shutter speed you would have available for this photograph?

Answer: 1/15"

Shutter Question #2:

You calculate a correct exposure of 1/125" @ f/16 for a particular scene. You want to make sure that there is no motion blur visible in your photograph. Your lens is capable of a maximum aperture size of f/2.8. What would be the fastest shutter speed you would have available for this photograph?

Answer: 1/4000" (assuming the camera supports a shutter speed that fast)

Additional Online References and Resources:

AGFAnet's Classical Photo Course

http://www.agfanet.com/en/cafe/photocourse/classiccourse/cont_index.php3

This is a very strong resource for photographers and it's completely free.

AGFAnet's Digital Photo Course

http://www.agfanet.com/en/cafe/photocourse/digicourse/cont_index.php3

A great resource for digital photographers.

BetterPhoto.com

<http://www.betterphoto.com>

BetterPhoto offers online classes with a host of renowned photographers.

Photo.net

<http://www.photo.net>

A great community of photographers online.

DPReview.com

<http://www.dpreview.com>

The best online resource for in depth reviews of digital cameras and equipment. This site also hosts large photographer discussion forums.

ShortCourses

<http://www.shortcourses.com/>

A complete resource for the digital photographer.

Revision History:

v1.0 – 10/19/2003	Original Release
v1.1 – 10/26/2003	Corrected some typos, miscellaneous formatting errors, and added the revision history. Added Stops and Exposure Question #4.