

UNDERSTANDING THE EXPOSURE TRIANGLE

Exposure is all about light. Exposure is the most crucial aspect of photography, thus it is difficult to take good pictures without having a solid understanding of ISO, Shutter Speed and Aperture – the Three Kings of Photography, also known as the “Exposure Triangle”. Let’s quickly review a summary of the Exposure Triangle as a refresher:

1. **ISO** – the level of sensitivity of your camera to available light. It is typically measured in numbers, a lower number representing lower sensitivity to available light, while higher numbers mean more sensitivity. More sensitivity comes at the cost though, as the ISO increases, so does the grain/noise in the images. Examples of ISO: 100, 200, 400, 800, 1600. Each value of the rating represents a “stop” of light, and each incremental ISO number (up or down) represents a doubling or halving of the sensor’s sensitivity to light.
2. **Shutter Speed** – the length of time a camera shutter is open to expose light into the camera sensor. Shutter speeds are typically measured in fractions of a second, when they are under a second. Slow shutter speeds allow more light into the camera sensor and are used for low-light and night photography, while fast shutter speeds help to freeze motion. Examples of shutter speeds: 1/15 (1/15th of a second), 1/30, 1/60, 1/125. Each shutter speed value also represents a “stop” of light.
3. **Aperture** – a hole within a lens, through which light travels into the camera body. The larger the hole, the more light passes to the camera sensor. Aperture also controls the depth of field, which is the portion of a scene that appears to be sharp. If the aperture is very small, the depth of field is large, while if the aperture is large, the depth of field is small. In photography, aperture is typically expressed in “f” numbers (also known as “focal ratio”, since the f-number is the ratio of the diameter of the lens aperture to the length of the lens). Examples of f-numbers are: f/1.4, f/2.0, f/2.8, f/4.0, f/5.6, f/8.0. Each f-number represents a “stop” of light.

These 3 factors all work proportionately to produce an exposure. When these three elements are combined, they represent a given exposure value (EV) for a given setting. Any change in any one of the three elements will have a measurable and specific impact on how the remaining two elements react to expose the image sensor and how the image ultimately looks. For example, if you increase the f-stop (higher f-stop), you decrease the size of the lens’ diaphragm thus reducing the amount of light hitting the image sensor, but also increasing the *DOF* (depth of field) in the final image. Reducing the shutter speed affects how *motion* is captured, in that this can cause the background or subject to become blurry. However, reducing shutter speed (keeping the shutter open longer) also increases the amount of light hitting the image sensor, so everything is brighter. Increasing the ISO, allows for shooting in lower light situations, but you increase the amount of digital *noise* inherent in the photo. It is impossible to make an independent change in one of the elements and not obtain an opposite effect in how the other elements affect the image, and ultimately change the tonal value of the image.

Aperture

A lens's aperture is the opening in the diaphragm that determines the amount of focused light passing through the lens. At a small f-stop, say $f/2$, a tremendous amount of light passes through, even at a fraction of a second; but at $f/22$, when the diaphragm is perhaps at its smallest, only a tiny amount of light is let in (even at longer shutter speeds). An interesting thing about the aperture and the f-numbers is that it doesn't matter the focal length of the lens as long as the f-number is held constant. This is because the arithmetical equation that determines the f-number indicates that the same amount of light passes through the lens on a 35mm lens as on a 100mm lens, with a shutter speed of $1/125$ s. The size of the diaphragm is unquestionably different, but the amount of light passing through is the same. Aperture also controls the depth of field or the range of distance over which objects appear to be in sharp focus. The larger the aperture (smaller f-stop number), the less range in distance objects will be in focus versus a smaller the aperture (larger f-stop number), where more of the photo will be in focus.

Aperture By the Numbers. Every time the f-stop value halves, the light-collecting area quadruples. There's a formula for this, but most photographers just memorize the f-stop numbers that correspond to each doubling/halving of light:

Aperture Setting	Relative Light	Example Shutter Speed
$f/22$	1X	16 seconds
$f/16$	2X	8 seconds
$f/11$	4X	4 seconds
$f/8.0$	8X	2 seconds
$f/5.6$	16X	1 second
$f/4.0$	32X	$1/2$ second
$f/2.8$	64X	$1/4$ second
$f/2.0$	128X	$1/8$ second
$f/1.4$	256X	$1/15$ second

The above aperture and shutter speed combinations all result in the same exposure.

Note: Shutter speed values are not always possible in increments of exactly double or half another shutter speed, but they're always close enough that the difference is negligible.

Shutter Speed

Shutter speed is measured in fractions of a second, and indicates how fast the curtains at the film plane open and close. The shutter speed controls how long light enters the

lens and hits the image sensor. The shutter speed enables you to capture the world in split seconds, but it can also absorb the world at speeds upwards of three and four seconds (or remain continually open up until the photographer wants to close the curtain - BULB setting). Snapping the shutter in a fraction of a second, also gives you control on how motion is recorded. If the shutter speed is faster than the object or background, then the image will be tack sharp. If the shutter speed is slower, then you'll get blurred objects. Think about the rain in a rainstorm, how fast is that water falling? At 1/30th the raindrops are streaks of undistinguishable white. At 1/250th, the raindrops hover in mid air and you can see the full swell of each water drop.

Here are some basic tips about shutter speeds to begin:

- To stop a racing car, or someone riding a bicycle, start with 1/1000 second.
- For everyday pictures such as portraits and views, use speeds of 1/60 second to 1/250 second.
- If the light is really bad, try not to go below 1/60 second. If you must, hold your camera very still and don't expect to freeze any action. OR, use a tripod to stabilize the camera so you can shoot at slow speeds without camera shake.

Shutter Speed By the Numbers. Shutter speed's influence on exposure is perhaps the simplest of the three camera settings: it correlates exactly 1:1 with the amount of light entering the camera. For example, when the exposure time doubles, the amount of light entering the camera doubles. It's also the setting that has the widest range of possibilities:

Shutter Speed	Typical Examples
1 - 30+ seconds	Specialty night and low-light photos on a tripod
2 - 1/2 second	To add a silky look to flowing water Landscape photos on a tripod for enhanced depth of field
1/2 to 1/30 second	To add motion blur to the background of a moving subject Carefully taken hand-held photos with stabilization
1/50 - 1/100 second	Typical hand-held photos without substantial zoom
1/250 - 1/500 second	To freeze everyday sports/action subject movement Hand-held photos with substantial zoom (telephoto lens)
1/1000 - 1/4000 second	To freeze extremely fast, up-close subject motion

Focal Length and Shutter Speed – another thing to consider when choosing shutter speed is the focal length of the lens you're using. Longer focal lengths will accentuate the amount of camera shake you have and so you'll need to choose a faster shutter speed (unless you have image stabilization in your lens or camera). The 'rule' of thumb to use with focal length in non image stabilized situations) is to choose a shutter speed with a denominator that is larger than the focal length of the lens. For example if you

have a lens that is 50mm 1/60th is probably ok but if you have a 200mm lens you'll probably want to shoot at around 1/250.

ISO Speed

ISO is actually an acronym, which stands for International Standards Organization. The ISO rating, which ranges in value from 25 to 3200 (or beyond), indicates the specific light sensitivity. The lower the ISO rating, the less sensitive the image sensor is and therefore the smoother the image, because there is less digital noise in the image. The higher the ISO rating (more sensitive) the stronger the image sensor has to work to establish an effective image, which thereby produces more digital noise (those multi-colored speckles in the shadows and in the midtones). So what is digital noise? It is any light signal that does not originate from the subject, and therefore creates random color in an image. ISO speed is usually only increased from its minimum value if the desired aperture and shutter speed aren't otherwise obtainable. The digital camera engineers have designed the image sensor to perform best at the lowest ISO (just like with film). On most digital cameras this is ISO between 100 and 6400, although some high end DSLRs have a mode that brings the ISO down to 50 or even 25 and up to over 25000.

When choosing the ISO setting generally ask the following four questions:

1. **Light** – Is the subject well lit?
2. **Grain** – Do I want a grainy shot or one without noise?
3. **Tripod** – Am I using a tripod?
4. **Moving Subject** – Is my subject moving or stationary?

If there is plenty of light, want little grain, using a tripod and the subject is stationary then generally use a pretty low ISO rating.

If it's dark, purposely want grain, don't have a tripod and/or the subject is moving then consider increasing the ISO as it will enable you to shoot with a faster shutter speed and still expose the shot well.

Of course the trade off of this increase in ISO will be noisier shots.

Situations where you might need to push ISO to higher settings include:

- **Indoor Sports Events** – where your subject is moving fast yet you may have limited light available.
- **Concerts** – also low in light and often 'no-flash' zones
- **Art Galleries, Churches** etc- many galleries have rules against using a flash and of course being indoors are not well lit.
- **Birthday Parties** – blowing out the candles in a dark room can give you a nice moody shot which would be ruined by a bright flash. Increasing the ISO can help capture the scene.

Summary: The geometric relationship of a triangle is that no single side or angle can be changed without making a compensating change to another side or angle. The same exact relationship exists between shutter speed, aperture, and ISO. Think of the Exposure Triangle starting out as an equilateral triangle with each leg being 6" long. Let's assume the ideal exposure is aperture at f8, shutter speed at 1/250 and ISO at 400. If we increase the shutter speed to 1/1000, we've gone up 2 full stops of speed. This doubles the length of the triangle on the shutter speed side. In order to keep that same ideal exposure keeping the ISO at 400, we need to let in 2 complete stops of light, therefore the aperture must go down 2 full stops to f4 to keep that same ideal exposure. The same thing happens if we decrease the ISO from 400 to 100. We are now letting in 2 full stops more light, therefore we must either increase the aperture from f8 to f16 (2 full stops creating less light) OR increase the shutter speed from 1/250 to 1/1000 (2 full stops creating less light) to keep that same exposure. Just remember - **if 1 side of the triangle increase or decreases, 1 other side of the triangle must either increase or decrease also.** This is easy to see in the below chart::

Exposure Valuations

Aperture	Shutter Speed		ISO
1	1	Sec	25
1.4	1/2	Sec	50
2	1/4	Sec	100
4	1/8	Sec	200
5.6	1/15	Sec	400
8	1/30	Sec	800
11	1/60	Sec	1600
16	1/125	Sec	3200
22	1/250	Sec	6400
32	1/500	Sec	12800
45	1/1000	Sec	25600
64	1/2000	Sec	51200
	1/4000	Sec	
	1/8000	Sec	

Each column is a typical 1 full stop setting for most cameras. Remember, if one of the columns increases or decreases, one of the other columns must also increase or decrease to keep the same exposure ratio.

Histogram

Before we can achieve the correct exposure it is important to know what a correctly exposed image looks like. A correctly exposed digital picture is a file that shows a full range of tones, from deep shadows to bright highlights, with detail across the entire image. You should see some detail in the dark shadow areas while at the same time retaining detail in the brighter highlight areas. Providing you get this, you can decide afterwards whether you actually need the full tonal range to appear when you print the image. If you don't ensure that you have the full tonal range from the start, there is little you can do about it later. This last point is more crucial when shooting in JPEG format. When shooting in RAW mode, getting the right exposure is a more forgiving process than it is when you shoot color negative film because you can correct the color in your computer later.

Understanding Histograms: As you've heard before, one of the best things about digital cameras is the ability to review your images on the back of your camera. When I harp on about checking the exposure on your LCD screen, sometimes I hear this: "In the sunlight I can hardly see the screen. How can I possibly judge my exposure?"

Most DSLR's have the facility to display a histogram on the camera LCD screen. Whereas 99 percent of photographers think a histogram is some sort of family tree, it is in fact a fairly simple bar chart. The chart illustrates how the pixels in an image are distributed by graphing the number of pixels at each color intensity level. This shows you whether the image contains enough detail in the shadows (shown on the left side of the histogram), mid-tones (shown in the middle), and highlights (shown on the right side) to create good overall exposure. As you get used to viewing histograms, you'll find them a great tool for checking and double-checking your photographs, especially in adverse lighting conditions. Knowing what sort of histogram a well-exposed image produces eliminates the chances of being fooled by an LCD screen that is not set to the correct brightness. If the histogram looks all right, it doesn't matter whether the image looks light or dark on the screen. The truth is in the histogram. A good exercise is to take some pictures of a subject with a full range of colors and tones. Set your camera to manual exposure and expose one frame as the meter suggests. Then take the same picture in a range of frames at half or one-third stop increments, from three stops under to three stops over. Look at the histograms of these pictures to learn how to read and understand them, taking into account how the chart varies with under and over exposure. Very, very crudely speaking— and I may get criticized for simplifying to this degree— you're looking for a mountain range in your histogram window that starts at one edge, finishes at the other edge, and reaches toward the top of the histogram frame. Obviously, since every picture has different content, your mountain ranges will vary. Also remember, there is no 1 correct histogram. As long as there is no bunching up all the way to the top on either the far left or far right side of the histogram (blown out blacks or whites), the details in the dark and light exposure is savable in post processing. Extremely blown out darks or whites cannot be saved as the detail in those areas are forever lost.