

Worksheet and Discussion: Exposure Settings and Reciprocity

by Steph Abegg, 2011.

Key Concept = Understanding Exposure

The exposure of a photograph is a function of the amount of light entering (or being recorded by) the camera. For a given scene, the amount of light entering (or being recorded by) the camera is controlled by three settings, which can be adjusted independently of the others:

- 1) **Aperture:** (the area of) the opening through which light travels into the camera; wider apertures (which are non-intuitively represented by smaller f-numbers) allow more light to enter the camera. A *standard sequence in one-stop increments of f-numbers from a narrow aperture to wide is: 32.0, 22.0, 16.0, 11.0, 8.0, 5.6, 4.0, 2.8, 2.0, 1.4.*
- 2) **Shutter speed:** the length of the exposure; longer shutter speeds allow more light to enter the camera for a given photograph. A *standard sequence in one-stop increments of shutter speed (in seconds) from short exposure to long is: 1/2000, 1/1000, 1/500, 1/250, 1/125, 1/60, 1/30, 1/15, 1/8, 1/4, 1/2, 1, ... (much longer for night photos).*
- 3) **ISO speed:** in film cameras, ISO refers to the film speed; in digital cameras, it represents the sensitivity of the sensor; higher ISO corresponds to higher sensitivity and allows the camera's film or sensor to record more of the incoming light. A *standard sequence in one-stop increments of ISO from low speed to high is: 50, 100, 200, 400, 800, 1600, 3200.*

Reciprocity of Exposure Settings

There is a reciprocal relationship between aperture, shutter speed, and ISO speed:

$$\text{Exposure} \sim \text{Aperture Area} \times \text{Exposure Time} \times \text{Film/Sensor Sensitivity (ISO)}$$

These three camera settings are calibrated in stops, or doublings and halvings. For instance, for a given scene, doubling the amount of light entering or being recorded by the camera can be achieved by:

1. Doubling the area of the aperture (i.e. decreasing the f-number by one stop)
2. Doubling the shutter time
3. Doubling the ISO

Reciprocity also means that a variety of aperture, shutter speed, and ISO combinations can produce the same exposure. A change in one camera setting can be counterbalanced by changing the other camera setting(s) by an equal number of (combined) stops in the opposite direction. For example, let's say a photo is correctly exposed with a shutter speed of 30 seconds, an aperture of f/8.0, and an ISO speed of 800. We might want to keep the shutter speed the same, but increase the depth of field (i.e. decrease the aperture size). In order to maintain the exposure, each stop in aperture requires the ISO to be increased by one stop. For example, the photo will be identically exposed with a shutter speed of 30 seconds (same), aperture of f/16 (2 stops), and ISO of 3200 (2 stops).

As an exercise of your understanding of the reciprocity of your camera's exposure settings, fill out the rest of the table on the following page. The first column has been filled out for the example discussed in the previous paragraph.

Exposure Setting	Exposure Stops	Example Values	Different Settings but Identical Exposure (<i>but identical exposure does not mean identical photograph!</i>)													
			Base Case	Same Shutter Speed, Change Aperture and ISO			Same Aperture, Change Shutter Speed and ISO			Same ISO, Change Shutter Speed and Aperture						
Shutter Speed	-2	7.5 sec														
	-1	15 sec														
	0	30 sec	X	X												
	+1	1 min														
	+2	2 min														
Aperture	-2	16.0			X											
	-1	11.0														
	0	8.0	X													
	+1	5.6														
	+2	4.0														
ISO	-2	200														
	-1	400														
	0	800	X													
	+1	1600														
	+2	3200			X											

Camera Noise

It is typical in night photography to use a high ISO setting to increase the sensitivity of the camera to incoming light. The downside is that high ISO leads to noise—the appearance of random "bad" pixels scattered over the photo. It is a similar effect as "grain" in film photography and it degrades the photo quality.

Manual Focus

In low light, the camera's automatic focus typically will not work. So when setting up a night photo, you usually need to use manual focus to make sure the main subject of the photograph is in focus. For landscapes and stars with no foreground objects, setting the focus to infinity is usually best. If you have a chance to set up your photo while it is still light enough to use automatic focus, you can set the focus this way and then turn off the automatic focus for the night photograph.

Handy Tip for Determining Nighttime Exposure Settings

If you are not sure what combination of exposure settings (shutter speed, aperture, ISO) to use, here's a quick-and-dirty technique that works pretty well. Set your camera at its highest ISO setting, its widest aperture, and a shutter speed of 30 seconds. After taking the photo, examine the photo's histogram on the camera (sorry film users, this trick only works with a digital camera). If the image is underexposed, increase the shutter speed until you get the correct exposure; if the image is overexposed, decrease the shutter speed (or decrease the ISO) until you get the correct exposure. Once you find the desirable exposure, "stop down" the ISO (since a lower ISO is desirable as it results in less noise) and "stop up" the shutter speed (towards longer exposure) or aperture (towards narrower aperture) by the same number of stops used to stop down the ISO. For long exposures, you usually need to add an extra half-stop to the exposure time, due to reciprocity failure at longer exposure lengths.

See Steph's website for more discussions relating to the technical aspects of night photography, such as reciprocity failure, camera noise, and exposure values. Her website also gives a table of typical exposure settings for various nighttime scenes. Best of all, she displays several of her favorite nighttime photographs along with their exposure settings. The url for this page is: <http://www.stephabeqq.com/home/photography/nightphotography>

Solution

Exposure Setting	Exposure Stops	Example Values	Different Settings but Identical Exposure (<i>but identical exposure does not mean identical photograph!</i>)													
			Base Case	Same Shutter Speed, Change Aperture and ISO				Same Aperture, Change Shutter Speed and ISO				Same ISO, Change Shutter Speed and Aperture				
Shutter Speed	-2	7.5 sec						X					X			
	-1	15 sec							X					X		
	0	30 sec	X	X	X	X										
	+1	1 min								X					X	
	+2	2 min									X					X
Aperture	-2	16.0		X												X
	-1	11.0			X									X		
	0	8.0	X					X	X	X	X					
	+1	5.6				X								X		
	+2	4.0					X						X			
ISO	-2	200					X				X					
	-1	400				X				X						
	0	800	X										X	X	X	X
	+1	1600		X					X							
	+2	3200		X					X							