

Photo I: Introduction

HOW A DIGITAL CAMERA WORKS

The lens brings light from the scene into focus inside the camera so it can expose an image.

The aperture is a hole that can be made smaller or larger to control the amount of light entering the camera.

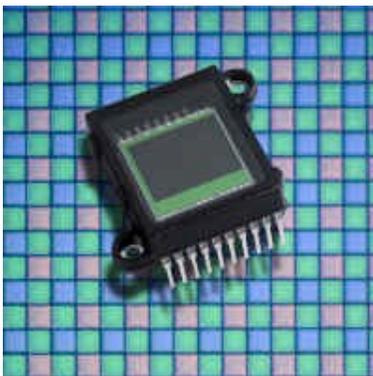
The shutter is a device that can be opened or closed to control the length of time the light enters.

The big difference between traditional film cameras and digital cameras is how they capture the image.

*You are using **electronic film**.* Instead of film, digital cameras use a solid-state device called an image sensor, usually a charge-couple device (CCD).

On the surface of each of these rectangle shaped silicon chips is a grid containing hundreds of thousands or millions of photosensitive diodes called photosites, photo elements - or pixels.

Each photosite captures a single pixel. Your images will consist of millions of pixels. Each mega-pixel measurement means: a unit of graphic resolution equivalent to one million or (strictly) $1,048,576$ (2^{20}) pixels.



The Exposure

When you press the shutter release button of a digital camera, a metering cell measures the light coming through the lens and sets the aperture and shutter speed for the correct exposure.

When the shutter opens for that nanosecond, each pixel on the image sensor records the brightness of the light that falls on it by accumulating an electrical charge.

The more light that hits a pixel, the higher the charge it records.

When the shutter closes to end the exposure, the charge from each pixel is measured and converted into a digital number. The series of numbers can then be used to reconstruct the image by setting the color and brightness of matching pixels on the screen or printed page.

Light Sensitivity ISO Ratings

An ISO (International Organization for Standardization) number that appears on the film package specifies the speed, or sensitivity, of a silver-based film. The higher the number the "faster" or more sensitive the film is to light.

Each doubling of the ISO number indicates a doubling in film speed so each subsequent film is double the speed of the preceding number.

Just like in the film days, Image sensors are also rated using equivalent ISO numbers. Just as with film, an image sensor with a lower ISO requires more light for a good exposure than one with a higher ISO.

To get more light, you need a longer exposure time that can lead to blurred images or a wider aperture that gives you less depth of field.

But what is ISO?

Your ISO allows you to make pictures in low light situations.

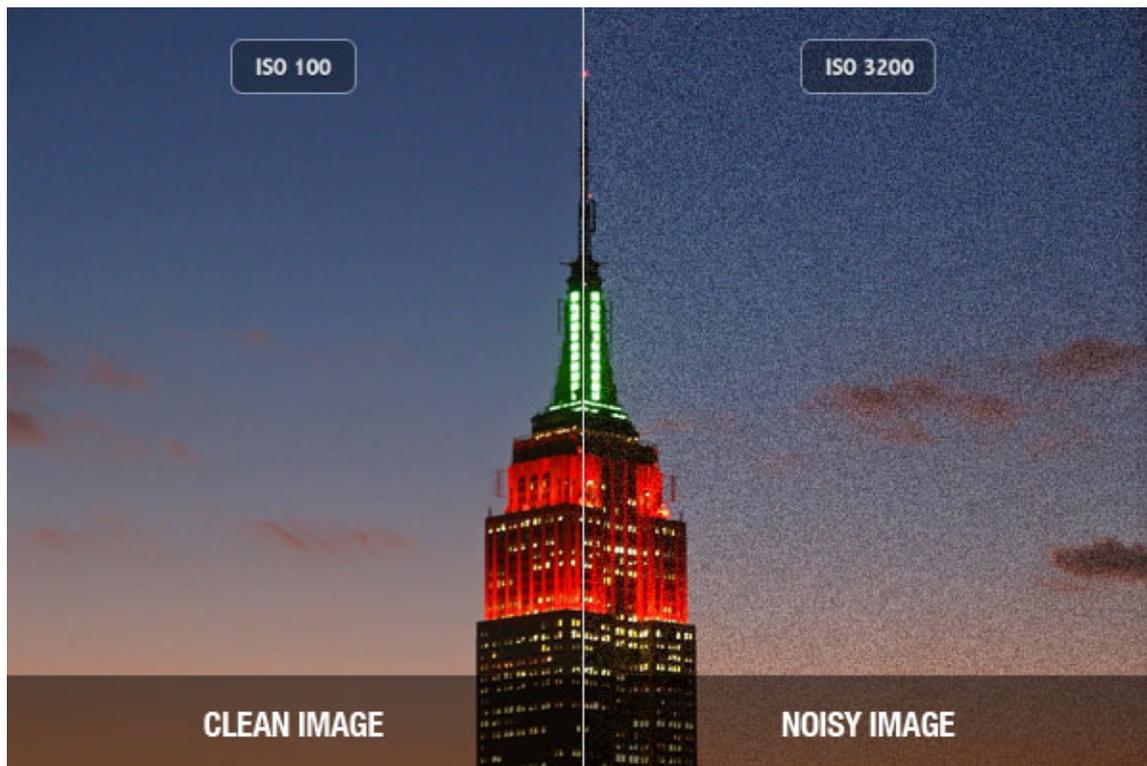
It is basically a measure of your digital sensor's sensitivity to light. The higher the number, the more sensitive to light your sensor becomes.

<https://digital-photography-school.com/iso-settings/>

Read more: <https://www.digitaltrends.com/photography/what-is-iso/>

DO THIS: Get in the habit of checking your ISO every time you create a photograph.

Many photographers have been disappointed at the end of a shoot to find that they had forgotten to check what ISO setting they had left their camera on during their last photography session. This can result in photographers assuming they are using an ISO of 100 only to find they forgot to switch the ISO back from 1600.



<https://www.exposureguide.com/iso-sensitivity/>

Photo credit: <http://www.exposureguide.com/iso-sensitivity.htm>

ISO Tip #1

Always shoot on the low ISO you can afford.

ISO Tip #2

At the end of each photography session, dial back your ISO to the lowest possible setting, then boost as needed.

ISO Tip #3

Avoid leaving the camera ISO setting on “Auto ISO.” Your camera will assume high ISOs in low light conditions.

Lenses



Focal Length:

The focal length of a lens indicates its magnifying power.

A “**normal**” lens (the spot between your wide angle and telephoto zoom, or around 50mm on a 35mm film camera) is great for general picture taking.

A **telephoto lens** (85mm and higher on a 35mm film camera, or the telephoto end of your zoom control) is great for photographing people at a distance, or animals—magnifying subjects from a distance.

A **wide-angle lens** (35mm and lower on a 35mm film camera, or the wide angle end of your zoom control) is great for capturing landscapes, groups of people and vacation photographs, as they can “see” a lot of a scene.

Sometimes straight lines can become distorted and close ups of people can be distorted by a wide-angle lens.



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More on lenses later: Watch for a separate lecture devoted to lenses.

Flash

Using flash has its advantages and disadvantages. Flash can blow out soft ambient lighting, changing what could be a gentle soft portrait into something harsh and unintended. Flash can capture a moment in time, uncovering an unseen world; imagine a drop of milk frozen forever by a burst of flash.

What is Good About Flash:

- ❖ You can freeze fast action due to the very brief duration of electronic flash.
- ❖ Fill flash fills in harsh shadows
- ❖ You can achieve dramatic effects at night or twilight if used with some thought.

What's Not So Great About Using Flash:

- ❖ Flash pictures often look like flash pictures, with very bright foregrounds and pitch-black dead backgrounds—you get the “snap shot” effect.

- ❖ Flash photography on people can be harsh, with sharp distracting shadows.
- ❖ Electronic flash can produce a “ghosting “ effect, which happens when the main exposure is made by the flash, and a secondary blurry exposure is produced when the available light is not strong enough.
- ❖ Some venues won’t let you use flash.

On most cameras, there are various flash modes you can choose from for more creative effects.

1) Auto Mode fires the flash whenever there is too little light for a good exposure or when the main subject is backlit.

2) Red-eye Reduction mode fires a first short burst to close the subjects’ irises before the picture is taken and the main flash fires. The symbol for this control usually looks like an Egyptian eye

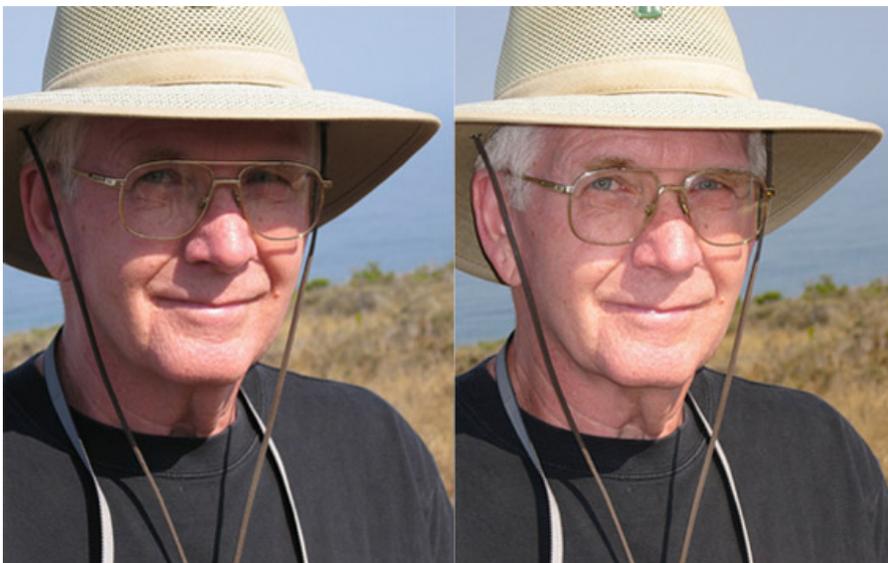
When photographing people, you'll often see images with what's called **red eye**. The light from a flash has entered through the subject's pupil and reflected off the retina at the back of the eye and then back out to the camera. Since the retina is full of thin blood vessels, it takes on a red color. Some flash units have a red-eye reduction mode.



3) Fill flash (forced) mode is used when there is enough natural light to take a picture, but you want to fill in shadows. This mode is great to use in harsh bright sunlight when the subject is back or side lit.

For more information, go to:

<https://www.exposureguide.com/camera-flash-types/fill-in-flash/>



One of the best uses of built-in flash units is to fill in dark shadows when photographing people or other subjects in bright sun. Without flash, shadow areas can be so dark in the image that they show little or no

detail. If the shadow covers a large part of the subject, the effect can be distracting and unattractive. You can lighten such shadows by using flash to "fill" the shadows to lighten them.

Flash Off Mode is used when the light is low enough to trigger the flash but you'd rather use a long exposure to capture it in natural light. A Must-have feature for product or macro photography.

CONTROLLING THE CAMERA: Get off Auto

All digital cameras give you fully automatic operation so you can just point and shoot to take pictures. If you want more creative control and power, it's important to understand how to override the automatic settings.

Basic Camera Controls

- 1) **Auto Exposure (Auto)** calculates the correct exposure for the scene.
Fully automatic selects both the aperture and shutter speed. Flash fires if the sensor detects low light. *Not recommended; photographer has little control over image.*
- 2) **Program Mode (P)** almost like Auto, except photographer can control flash. Camera automatically picks shutter speed and aperture based. Photographer only has control over flash.

More control for photographer:

- 3) **Aperture Priority (AV or A)** lets you select the aperture (to control depth of field) and the camera then selects the best matching shutter speed for a good exposure.
- 4) **Shutter Priority (TV or S)** lets you select the shutter speed (to control motion) and the camera then selects the best matching aperture for a good exposure.
- 5) **Manual Mode (M)** gives photographer full control over shutter speed and aperture selection for full creative control.

Other controls:

- 6) **Automatic focus (AF)** brings the center of interest into sharp focus. Some cameras have focusing squares, some cameras have face recognition.
- 7) **White balance (WB)** adjusts the colors in the image to match the source of light illuminating the scene.

Many people never find the need to progress beyond the fully automatic “point and shoot” kind of photography.

To be truly in control of your images, it's well worth it to know your manual controls to get some spectacular images, giving you a new way to see the world. Interpret your unique vision onto some great photographs and really have some fun.

Your Camera Has a Built-in Light Meter.

To measure the light reflecting from the scene, a camera uses a built in light meter.

Which part of the scene they measure makes a huge difference in how your photographs will look.

Many meters read the entire image area but give more emphasis to the bottom part of the scene because this reduces the possibility that the bright sky will cause the picture to be underexposed.

- ❖ **Center-weighted:** Metering that emphasizes the center of the image area on the assumption your subject to focus on is going to be in the middle of a scene. This is called a center-weighted system.
- ❖ **Spot Metering:** Some cameras let you select a small area of the scene and meter it directly using a spot meter. In this mode, only the part of the scene in the very center of the viewfinder is metered. Everything else is ignored.
- ❖ **Evaluative Metering:** Meter reads all points in a scene and determines the exposure.

metering modes

nikon



matrix metering

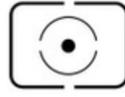


center-weighted
metering

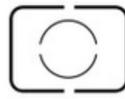


spot metering

canon



evaluative metering



partial metering



spot metering



center-weighted
metering

You can use **auto exposure** more successfully if you know a little about how it "thinks." All systems are calibrated on the assumption that in most scenes there will be a few dark shadows, many gray mid-tones, and a few bright highlights, and that all of these tones will average out to a tone of medium brightness called **middle gray**.

When the meter reads the brightness of a scene, it simply calculates an exposure that will reproduce a tone of that brightness correctly as **middle gray**. If you photograph a white wall, a gray wall, and a black wall, the camera will make them all gray in the photographs.

To render them in the image, the way they actually appear in real life, you use **exposure compensation (EV)**, **more details to follow**

For more information:

<https://digital-photography-school.com/metering-modes-and-how-your-camera-meter-works/>

Comparing metering modes:

<http://www.wild-eye.co.za/using-metering-modes-in-wildlife-photography/>

Exposure Control

The Photographic Triangle



How to make an image brighter or darker

There are three factors that affect how bright your image looks:

- 1) **Aperture:** the size of the opening in the lens when a photograph is taken.
- 2) **Shutter Speed:** The amount of time that the shutter is open.
- 3) **ISO:** The measure of a digital camera sensor's sensitivity to light

APERTURE - Defines the size of the opening in the lens. Aperture is metered in f-numbers. Today, digital cameras allow you to change aperture in 1/2 or 1/3 ev steps.

Aperture settings are called f-stops and each f-stop lets in half as much light as the next larger opening and twice as much light as the next smaller opening.

f/1, f/1.4, f/2, f/2.8, f/4, f/5.6, f/8, f/11, f/16, f/22, f/32

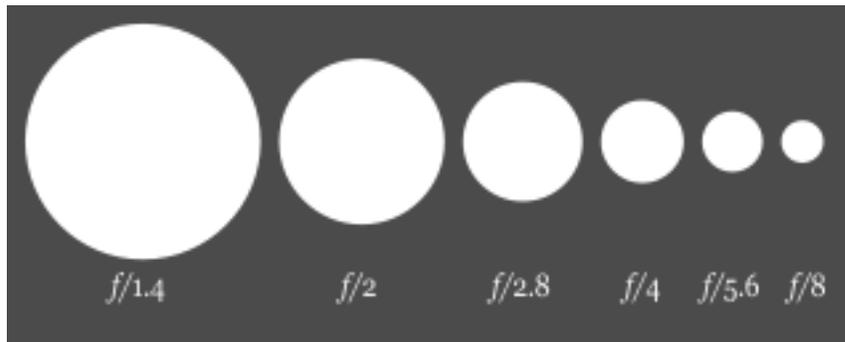


Diagram of decreasing apertures, that is, increasing f-numbers, in one-stop increments; each aperture has half the light gathering area of the previous one. The actual size of the aperture will depend on the focal length of the lens.

Typical one-third-stop f-number scale

f/#	1.0	1.1	1.2	1.4	1.6	1.8	2	2.2	2.5	2.8	3.2	3.5	4	4.5	5.0	5.6	6.3	7.1	8	9	10	11	13	14	16	18	20	22
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Imagine your camera is like a window with shutters that open and close.

Aperture is the size of the window. If it's bigger more light gets through and the room is brighter.

Shutter Speed is the amount of time that the shutters of the window are open. The longer you leave them open the more that comes in.

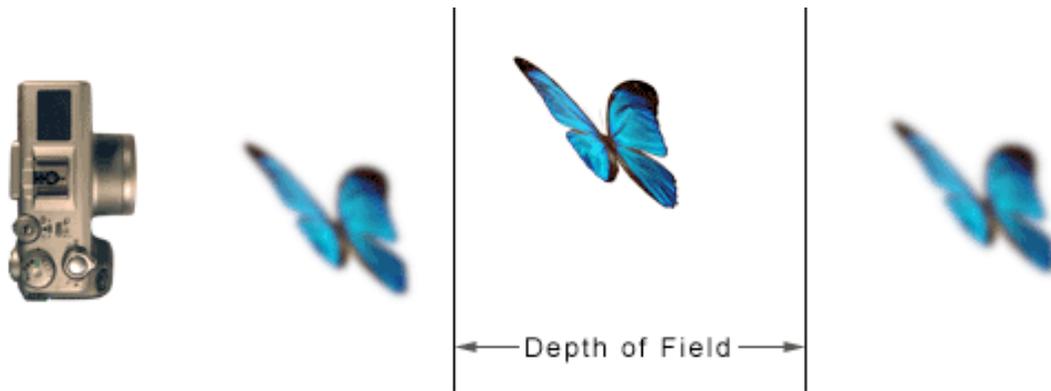
There are a number of ways of increasing the amount of light in the room.

You could increase the time that the shutters are open (decrease shutter speed), you could increase the size of the window (increase aperture).

Read more: <http://digital-photography-school.com/learning-exposure-in-digital-photography#ixzz0wKJQ14xT>

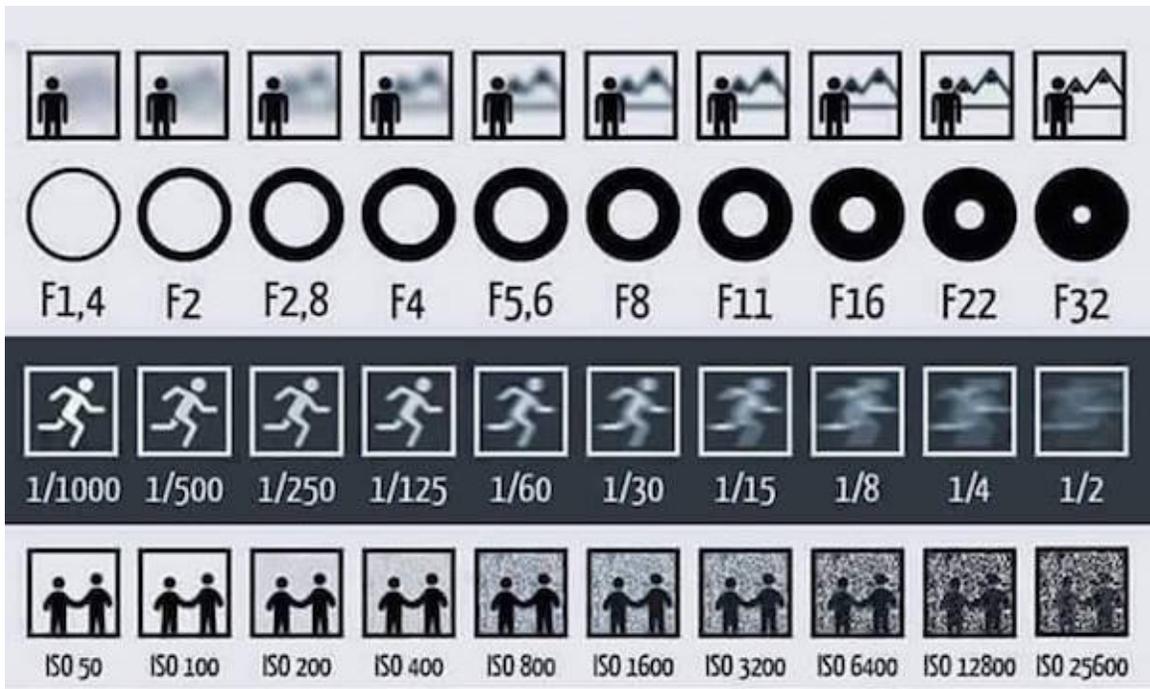
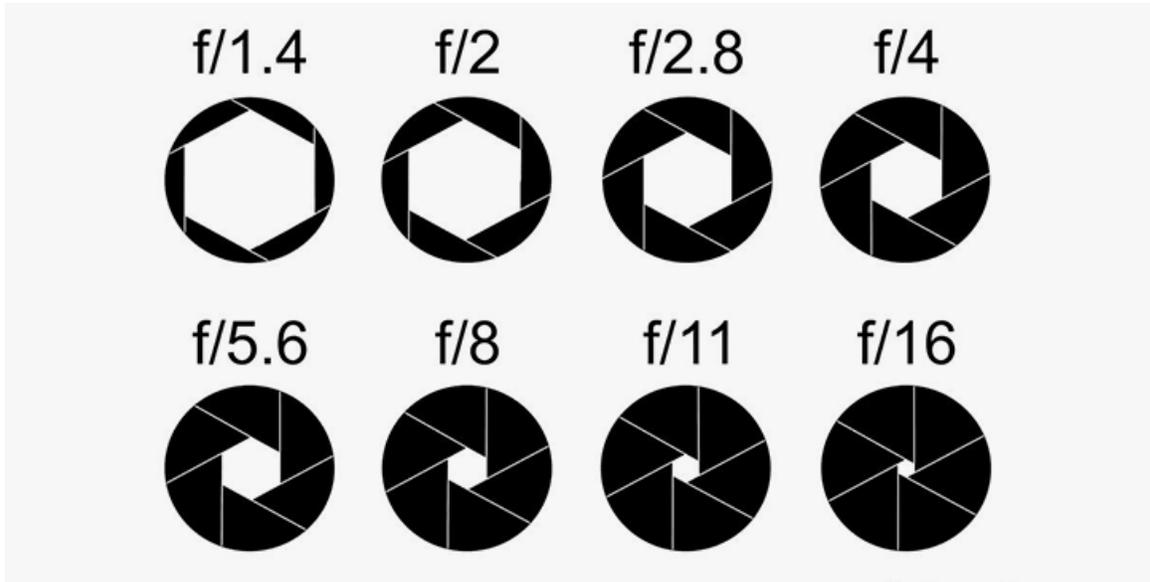
Aperture Control: Depth of Field – Selective Focus

If you can control your camera's **aperture**, you can control **depth of field**—the area from foreground to background that's sharp in the image. This allows you to either throw the background out of focus or keep both the subject and the foreground sharp; you can better predict your photograph's results.



What a lens looks like, opened up to full aperture opening (right), and stopped down (left):







Narrow DOF: Selective focus Brings attention to your focal point.



f/22 (Narrow Aperture)
Too Much in Focus



f/5.6 (Fairly Wide Aperture)
Background Blurred More



f/2.8 (Wide Aperture)
Background is Undistracting

Need inspiration?

<https://www.pinterest.com/com110/depth-of-field-assignment-10/>

<http://petapixel.com/2009/05/23/using-a-shallow-depth-of-field-for-portrait/>



Jonquils at F32: Maximum Depth of Field



Jonquils at F5: Shallow Depth of Field

BOKEH - Fun with Narrow Depth of Field (DOF)

In photography, **bokeh** (Originally /'boʊkɛ/, /'boʊkeɪ/ BOH-kay — also sometimes pronounced as /'boʊkə/ BOH-kə, Japanese: [boke]) is the aesthetic quality of the blur produced in the out-of-focus parts of an image produced by a lens. **Bokeh** has been defined as "the way the lens renders out-of-focus points of light".



Find out how to make this happen:

http://www.diyphotography.net/diy_create_your_own_bokeh/

Shutter Speed

The Shutter is a “curtain” directly in front of the camera’s sensor that raises up to expose the sensor to the scene, or “light” when you press the button to take a picture. While the Shutter is raised, light travels through the lens, past the aperture, and hits the sensor to create the picture. The Shutter then drops back down and cuts the sensor off from light once again.

Shutter Speed is the length of time the Shutter stays open when the picture is taken. You can set the shutter speed from fractions of a second, to minutes, hours, or as long as you want in theory.

What does the Shutter Speed do in a Photo?

The Shutter Speed Freezes or Blurs Motion

If a fast shutter speed is used, little movement can happen, so objects appear frozen, resulting in a sharp picture. If a slow shutter speed is used, objects can move during that time and become blurry. If you hand-hold the camera while creating a photograph, the camera itself is moving because nobody can hold it *perfectly* still, and the entire photograph may be blurry if the shutter speed is too slow.

The Shutter Speed controls how long light hits the sensor



<http://www.wildernessshots.com/how-to-use-shutter-speed/>
(short video showing the effect of time on water)

Shutter Speeds: Choosing a faster shutter speed allows you to freeze faster actions. You can control your shutter speed by selecting “shutter priority” mode and selecting either a low or a high shutter speed to get a desired effect.

Fast shutter speed: Experiment with selecting shutter speeds in excess of 1,000/second. You will need a lot of light and or boost ISO to get the proper exposure; your aperture will automatically select a wide open setting to allow enough light.



By Ken Furuta 1/3200 sec

A fast shutter speed can freeze a hummingbird in flight. Freeze water in motion or use a slow shutter speed to show the graceful cascade of water in a waterfall.

Effects of Shutter Speed
on Motion Blur

Photos by: Gregory F. Maxwell



1 sec



1/3



1/30



1/200



1/800

Fun with fast shutter speeds:









Slow shutter speeds make magic and convey motion in a still photograph:





Michael Bray, 1/13th sec.





SHUTTER SPEED CHART

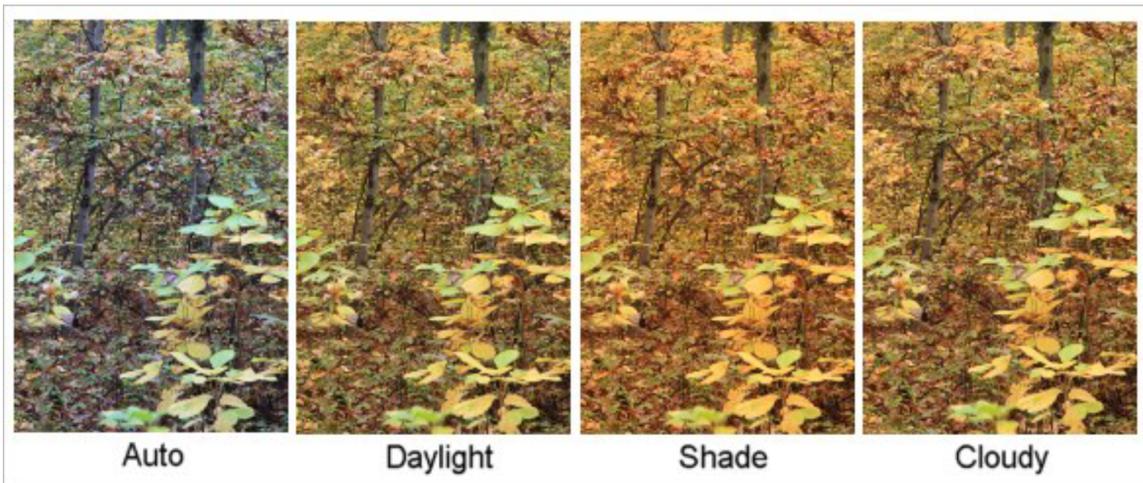
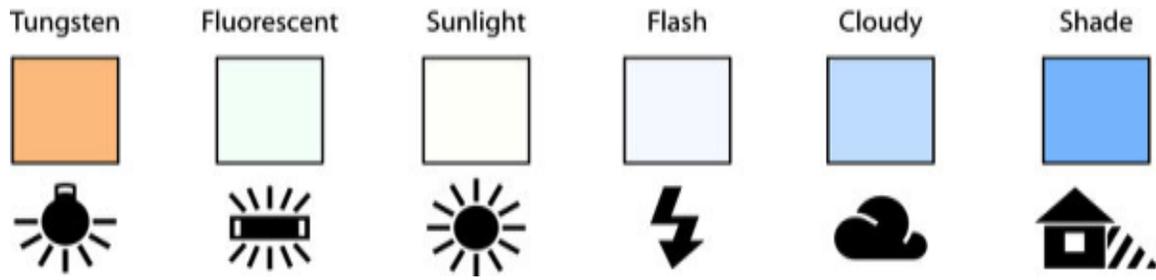


FULL STOP	1/2 STOP	1/3 STOP	SAFE SHUTTER SPEED	LIGHT	TYPES OF SHOOTING
1/2000	1/2000	1/2000			 BIRDS IN FLIGHT 1/2000
	1/1500	1/1600 1/1250			
1/1000	1/1000	1/1000			 ACTION SPORTS 1/500 - 1/1000
	1/750	1/800 1/640			
1/500	1/500	1/500			 STREET PHOTOS 1/250 - 1/500
	1/350	1/400 1/320			
1/250	1/250	1/250			 LANDSCAPES 1/125 - 1/4
	1/180	1/200 1/160			
1/125	1/125	1/125			 PANNING CARS 1/15 - 1/60
	1/90	1/100 1/80			
1/60	1/60	1/60			 WATERFALLS 1/8 - 2 sec
	1/45	1/50 1/40			
1/30	1/30	1/30			
	1/20	1/25 1/20			
1/15	1/15	1/15			
	1/10	1/13 1/10			
1/8	1/8	1/8			
	1/6	1/6 1/5			
1/4	1/4	1/4			
	0.3	0.3 0.4			

White Balance

Even a pure white object changes color when the light shining on it changes. Daylight is a cold clear light but adds some heavy overcast or step into the shade and acquires a bluish tint. In a room lit with incandescent light bulbs, the light has a warm orange glow to it, while under fluorescent fixtures, colors take on an eerie yellow/greenish tint.

Many cameras give you a choice of white balance settings, indicated by icons such as a sun, a cloud, shade or a light bulb. For example, you should be able to choose among white balance for sunny, incandescent, fluorescent, cloudy, and flash light. The camera compensates for different lighting conditions, correcting for the color shifts.



For more details on white balance, check out this resource:

<https://www.digitalcameraworld.com/tutorials/cheat-sheet-white-balance-settings>
<https://xinacat.smugmug.com/Sample-Photos/>

Exposure Compensation

Exposure Control & Exposure Compensation + -

The EV button allows you to quickly underexpose (darken) or overexpose (brighten) your image



The most common form of **override** for creative control is called **exposure compensation**, or “EV.”

This control allows you to select settings. They are expressed by

+1 = Adding 1 stop to exposure, adding 2x as much light.

+2 = Adding 2 stops to exposure, adding 2x more light.

+3 = Adding 3 stops to exposure, adding 2x more light.

0 Back to neutral = medium gray, average exposure

-1 = Subtracting 1 stop, taking away ½ the light.

-2 = Subtracting 2 stops, taking away ¼ the light.

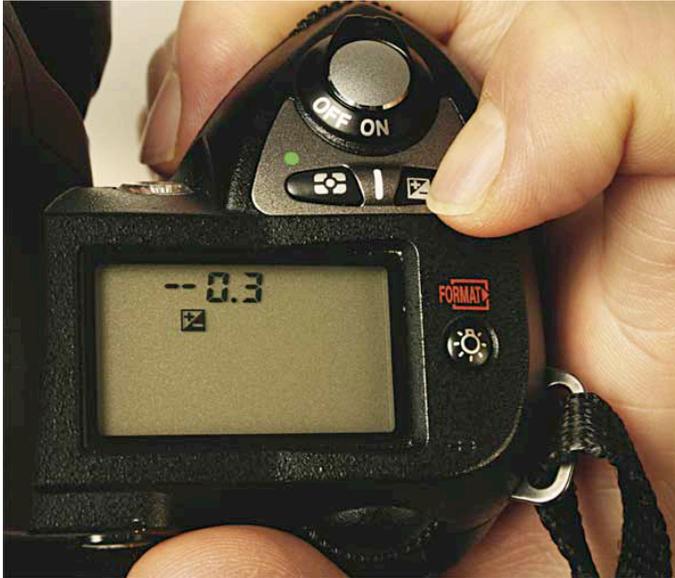
-3 = Subtracting 3 stops, taking away 1/8 the light.

This EV + or 1 button increases or decreases the exposure, as needed. Changing this setting is essential in settings where metering gets confused, as in brightly backlit scenes or scenes on bright sand or snow.

With exposure compensation, you can lighten or darken the image.

If you have a white cat on a snowfield or a black dog in front of a pile of coal, or a moody night scene, you will need to use EV controls.

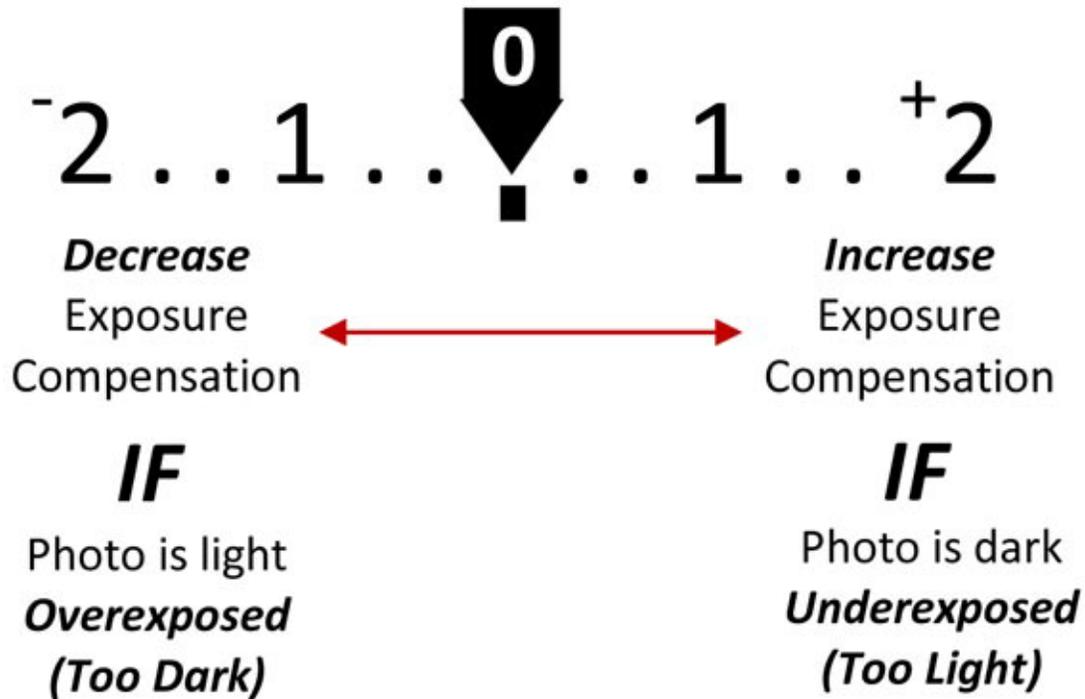
What does this look like?



Why do we care?

<https://xinacat.smugmug.com/Sample-Photos/i-5sWKWD9>

EXPOSURE COMPENSATION



© Laura Hoffman



+2 EV 1/100 F/5 ISO 200 Lens Focal Length = 56mm



Histogram

+2 EV

© Laura Hoffman



+1 EV 1/160 F/6.3 ISO 200 Lens Focal Length = 56mm



Histogram

+1 EV



0 EV 1/200 F/9 ISO 200 Lens Focal Length = 56mm

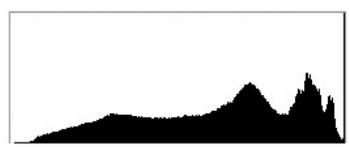


Histogram

0 EV



-1 EV 1/250 F/8 ISO 200 Lens Focal Length = 56mm

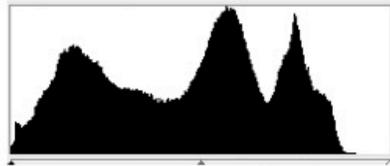


Histogram

-1 EV



-2 EV 1/400 F/10 ISO 200 Lens Focal Length = 56mm



Histogram

-2 EV



Moonrise over the San Jacinto Mountains
1/60th sec., focal length: 70mm DX, f/4.5, ISO 200, **-2 EV Aperture Priority**



After the sun set in Molokai, Hawaii:
1/15th sec., focal length: 28mm, f/3.8, ISO 640, **-2 EV Aperture Priority**